SD
J89

# THE JOURNAL OF WILDLIFE MANAGEMENT

UNIVERSITY OF MICHIGAN
NOV 7 1956
FORESTRY LIBRARY

OCTOBER - 1956
Vol. 20 No. 4

## CONTENTS


Waterfowl Nesting Islands — *M. C. Hammond and G. E. Mann* 345

Observations on Factors Affecting Smallmouth Bass Production in Iowa — *Robert E. Cleary* 353

Chemical Composition of Herbage Browsed by Deer in Two Wildlife Management Areas — *Frank H. Smith, Kenneth C. Beeson, and Walter E. Price* 359

Watering Patterns of Some Desert Game Animals — *James B. Elder* 368

Changes in Norway Rat Populations Induced by Introduction of Rats — *David E. Davis and John J. Christian* 378

Waterfowl Sex Ratios During Spring in Washington State and Their Interpretation — *Paul A. Johnsgard and Irven O. Buss* 384

Reclamation of Potential Trout Ponds in Maine — *Robert E. Foye* 389

Impaction and Pressure Necrosis in Canada Geese Due to Eating Dry Hulled Soybeans — *A. J. Durant* 399

Effect of Slash Burn on Forest Mice — *Lloyd Tevis, Jr.* 405

Productivity of Canada Geese in the Flathead Valley, Montana — *Mary Barraclough Geis* 409

Annual Survival of Massachusetts Male Woodcocks — *William G. Sheldon* 420

Breeding Density and Productivity of Mourning Doves on a County-wide Basis in Georgia — *Jack I. Lowe* 428

Stimulating Regrowth of Mountain Maple for Deer Browse by Herbicides, Cutting, and Fire — *L. W. Krefting, H. L. Hansen, and M. H. Stenlund* 434

Waterfowl Production During Wet and Dry Years in North-central Colorado — *Lee E. Yeager and Harold M. Swope* 442

Obituaries 446

Reviews 447

Briefer Articles—A simple automatic photographic unit for wildlife research, by *L. W. Gysel and E. M. Davis, Jr.*; Prolactin: an evaluation of its use in ring-necked pheasant propagation, by *C. G. Crispens, Jr.*; Television as a wildlife-education medium, by *D. L. Gilbert*; Minimum lethal temperature for the cottontail parasite *Eimeria environ*, by *D. H. Ecke*; Aransas wildlife introductions, by *A. F. Halloran and J. A. Howard*; Protecting grain fields in Japan from pilferage by birds, by *H. E. McClure*; Two marking devices for large land mammals, by *R. D. Taber, A. de Vos, and M. Altmann*; An observation concerning the validity of coot brood counts, by *G. W. Gullion*; The artificial roost—an aid in population studies, by *V. L. Yadon*; A technique for closing gates on big-game live traps by remote control, by *L. G. Sugden* 451

Index 468



The Journal of Wildlife Management is published by The Wildlife Society in January, April, July and October. Subscription $6.00 per year and current numbers $1.50. Society members cover subscription in annual dues. Back issues are available at $8.00 per volume, $2.00 per issue except the following, which are out of print: Vol. 1, Nos. 1 & 2; Vol. 2, Nos. 2, 3 & 4; Vol. 3, all issues; Vol. 5, No. 3; Vol. 7, Nos. 1 & 3; and Vol. 8, No. 1.

Manuscripts for publication, books and papers for review, news notes and correspondence concerning them should be sent to the *Editor*, Joseph J. Hickey, 424 University Farm Place, Madison 5, Wisconsin.

Dues, subscriptions, changes of address, requests for missing numbers, applications for membership, and other correspondence should be sent to the *Secretary-Treasurer*, Daniel L. Leedy, Branch of Wildlife Research, U. S. Fish and Wildlife Service, Washington 25, D.C.

The Society is not responsible for supplying missing issues unless the Secretary-Treasurer is notified within 60 days of the date of publication.

Entered as Second Class Matter, at the Post Office at Lawrence, Kansas, under the Act of March 3, 1879. Additional entry at Ithaca, New York.

Articles in this Journal are indexed in the Agricultural Index, available in many libraries.

THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 20 OCTOBER 1956 NUMBER 4

# WATERFOWL NESTING ISLANDS[1]

*M. C. Hammond and G. E. Mann*

U.S. Fish and Wildlife Service,
Upham, North Dakota, and Fergus Falls, Minnesota

There has recently been an increasing amount of interest in the development of islands for nesting waterfowl, as evidenced by inquiries received by the Fish and Wildlife Service.

Questions have primarily involved the following: (1) island construction—size, shape, location, and cost; (2) the use that might be expected; (3) values of points or other land masses surrounded by a channel or moat; (4) territorial characteristics of nesting concentrations; and (5) the relationships between island waterfowl nesting concentrations and reduction of habitat, as through drainage.

These notes have assembled the data available on some 70 Lower Souris National Wildlife Refuge (North Dakota) islands constructed in 1935 and general observations made by the senior author in North Dakota, South Dakota, Nebraska, and the Prairie Provinces.

It is well established that nesting waterfowl are frequently attracted to islands in numbers seldom found on the mainlands. Bent (1923, 1925) describes this habit for many wildfowl species; Gross (1945) reported concentrations of nesting black ducks (*Anas rubripes*) on the outer coastal islands of Maine; Miller and Collins (1954) recorded heavy use of islands by ducks on the Tule Lake and Lower Klamath National Wildlife refuges. There are many examples for the Canada Goose (*Branta canadensis*) (Jensen and Nelson *in* Williams, *et al.*, 1948; Craighead and Craighead, 1949; Kossack, 1950; Miller and Collins, 1953; and Naylor, 1953). Nevertheless, the simple fact that a land mass is surrounded by water does not guarantee its acceptance by ducks and geese or the success of nesting upon it.

## FACTORS RESPONSIBLE FOR ISLAND-NESTING CONCENTRATIONS

There is some question as to whether or not islands hold any basic attractiveness as a habitat type and if they are instinctively selected as optimum nesting sites. F. C. R. Jourdain (in notes supplied Bent, 1925:201) suggests that certain geese have acquired the habit of nesting in inaccessible places to avoid molestation by foxes in the Arctic. We may say, at least, that geese and many ducks quickly learn to take advantage of the sites where predation is avoided.

Certain characteristics of many true islands have obvious values. Among them are: (1) relative freedom from disturbances by mammals or birds; (2) a greater capacity for territorial occupancy because of the high ratio of water-land edge to land mass; and (3) close proximity of water, food, loafing (or lookout) sites, and nesting cover.

When nest losses are low for a period of several years, high production may lead to good annual survival and, through "homing" (Sowls, 1949), increase the number of potential nesting birds.

The gradual build-up of populations may reach a point where a scarcity of good nest sites occurs, and heavy use is made of those available. This sequence was observed with the Lower Souris Canada goose flock which

[1] Some of the field data were recorded by C. J. Henry and Donald V. Gray, Fish and Wildlife Service. We also wish to acknowledge suggestions and editorial advice by H. A. Hochbaum and Frank McKinney, Delta Waterfowl Research Station; Lyle K. Sowls, Arizona Coop. Wildl. Res. Unit, Univ. of Arizona; Mrs. Margaret M. Nice, Chicago, Ill.; Laurence R. Jahn, Wisconsin Conservation Dept.; C. T. Rollings, J. D. Smith and J. J. Wilson of the Fish and Wildlife Service; and J. W. Kimball, Minnesota Department of Conservation.

originated from 11 hand-raised, pinioned pairs acquired in 1937 and 28 full-winged, wild-captured birds released in 1939 (Hammond, 1950).

Goose nesting in early years was dispersed to one, or occasionally two, nests per island. If two per area, they occurred 200 to 300 feet or more apart. By 1953, with a breeding population of about 65 pairs, the birds had adjusted to relatively close nesting, in a few instances 50 to 60 feet apart (7 to 12 nests per island, about 16 per acre). The increasing tolerance extended through 8 years, the recent period of rapid population increase.

There has been a decided tendency for ducks to concentrate on only a few of the open-water islands. While most may have 10 to 30 nests, only two are known to have had a hundred or more. We suspect that social attractions play an important part in this and that the territorial and breeding displays may tend to draw pairs from surrounding areas, once the aggregations reach a certain level (Armstrong, 1947:175-182, 344-347).

Gadwalls (*Anas strepera*) seem particularly responsive to this phenomenon (Bent, 1923:77-79; Miller and Collins, 1954:31; and, we suspect, the Bear River Refuge concentrations described by Williams and Marshall, 1938).

As the population builds up, there is constriction of (1) territorial activity by birds occupying the island margin and (2) use of other areas during the brief period required for coition. The eventual limits are reached through (1) increasing social conflicts and attending egg loss; (2) exodus of pairs to other islands or mainland areas for nesting purposes; (3) gradually increasing losses to minor predators; and (4) periodic catastrophic loss, e.g., predation, flooding, and weather.

Our information about the various aspects of gadwall territoriality was rather sketchy. It did appear that birds from the margins of the impoundment flew to the islands to nest. The frequent pursuits by "resident" drakes failed to prevent the new-coming hens from nesting.

## SPECIES COMPOSITION

While all resident waterfowl species commonly nest on islands, it appears that geese and gadwalls have the greatest inclination to attain unusual densities. Mallards (*Anas platyrhynchos*), and sometimes pintails (*A. acuta*), reach greater proportions than would be expected from their normal behavior in other environments (Table 1). Bent (1923: 90) describes a small concentration of baldpates (*Mareca americana*). The numbers of blue-wings (*Anas discors*) and shovellers (*Spatula clypeata*) he found on the Crane Lake island (p. 113) are about what might be expected on the basis of the length of shoreline involved.

TABLE 1. – SPECIES COMPOSITION OF DUCK NESTS FOUND ON ISLANDS OF LOWER SOURIS NATIONAL WILDLIFE REFUGE (1935-1953)[1]

| Species | Number of nests | Per cent |
|---|---|---|
| Gadwall (*Anas strepera*) | 356 | 61 |
| Mallard (*Anas platyrhynchos*) | 135 | 23 |
| Pintail (*Anas acuta*) | 45 | 8 |
| Scaup (*Aythya affinis*) | 13 | 2 |
| Redhead (*Aythya americana*) | 12 | 2 |
| Blue-winged teal (*Anas discors*) | 9 | 3 |
| American widgeon (*Mareca americana*) | 3 | |
| Shoveller (*Spatula clypeata*) | 3 | |
| Canvas-back (*Aythya valisineria*) | 2 | |
| Ruddy duck (*Oxyura jamaicensis*) | 2 | |
| Totals | 580 | 99 |

[1] In the North Dakota duck-breeding population blue-wings and pintails are about equal in abundance, followed by mallards, shovellers, and gadwalls (Hjelle, *in* Crissey, 1951:149).

Redheads (*Aythya americana*) and lesser scaup ducks (*A. affinis*) are attracted to the smaller islands. The few redhead dry-land nesting sites we have observed were only a foot or so from the water's edge on mainland areas. Island nests are frequently found 15 to 20 feet from water and on Lacreek Refuge (South Dakota) an extreme distance of 50 feet was noted by Hammond. A series of small mounds thrown up in the early drainage of the Souris marshes provides secure sites a foot or so above the water line for many nesting redheads. In Bent (*loc. cit.*, 208, 218) are further descriptions of island-nesting scaup.

Greater scaups (*Aythya marila*) and old-squaws (*Clangula hyemalis*) were apparently the commonest island nesters on Mývatn, a lake in northeastern Iceland (Scott, 1952: 125-132).

These notes would indicate that only moderate use of islands would normally be expected for most ducks. But where gadwalls were common, there would be a good possibility of finding the spectacular concen-

trations. Considering their frequent use by this species, the Canada goose, mallards, scaups, and redheads, it would seem that island construction would often be an important management practice.

### VEGETATION

Preferred goose-nesting sites are usually so located that vegetative cover seems of minor importance. At times the cover may be too dense and tall; however, it may be used as a base upon which the nest is constructed. Nests are often built upon bare ground (Miller and Collins, 1953:391; Naylor, 1953; Kossack, 1950; Yocom, 1952; Craighead and Craighead, 1949).

The last-mentioned writers found some nests that were well concealed (p. 54). The only well-concealed nests found on Lower Souris were two known renestings in 1954. The original nests were on the island crest in low, dead weeds and grass. Following their destruction, the new nestings were located 5 feet and about 100 feet away in depressions, in one case just inside the edge of a moderately dense *Phragmites* patch. Laying was still in progress when the nests were found, and the eggs were completely covered with about two inches of dead leaves and stems.

Yocom (1952) noted that Canadas on the Snake River (Washington) ". . . show a preference for nest sites near logs or driftwood." In 1956 a few Lower Souris geese built their nests on small hay piles placed on several bare, newly constructed islands.

In general, cover also seemed of secondary importance to the common island-nesting ducks. Where there was a choice between dense weeds (Canada thistle, *Cirsium arvense*, and nettle, *Urtica procera*) and grass, the weeds were clearly preferred by both gadwalls and mallards. With a choice between these weeds and open, thinly vegetated sites, the dense cover was also preferred. On all islands many nests were started when cover was insufficient to provide much screening for them. Miller and Collins (1954:34-35) also recorded a preference for cover sites, such as nettle, offering good concealment for gadwalls and mallards.

Management of the Lower Souris islands has principally involved the removal of willow (*Salix* spp.) growth by cutting and spraying with weed killers. Natural revegetation by weeds and grasses has been adequate to prevent serious top erosion from rains.

Extensive beds of pondweed (*Potamogeton* spp.) in the shallow waters surrounding the islands may have been important in their concentrated use. An abundance of food has been available during the gadwall nesting season.

### NESTING LOSSES

Island nesters are subject to the same vagaries of the weather as those birds nesting on the mainland. In addition there is sometimes a greater danger from flooding. Errington (1946: 175-177) discusses the hazards to which island- and colonial-nesting birds may be subjected. Predation remains the primary mortality factor, whether it occurs periodically through accidental stranding or invasion of the island by a mammal, or through chronic susceptibility to egg-eating birds.

Bent (1923:78-79) describes an island (approximately 9 acres in size) in Crane Lake, Saskatchewan, visited with H. K. Job in June 1905. This supported an estimated 150 pairs of nesting ducks. In 1906 he found the site practically deserted and evidence that a coyote (*Canis latrans*) living there had ". . . cleaned out all of the nests, and driven the ducks away."

Salter (*in* Williams, *et al.*, 1950: 126-127) found high mammalian nest predation on islands in the Glenns Ferry area of the Snake River, Idaho, in 1950.

Kalmbach (1937:4, 26) found crows (*Corvus brachyrhynchos*) to be the principal hazard to island-nesting ducks in the Cooking Lake District of Alberta. These islands either furnished crow-nesting sites or were regularly visited by crows from the mainland one-half or one mile away.

On June 30, 1936, C. J. Henry, E. R. Kalmbach, W. F. Kubichek, and Neil Hotchkiss found 63 birds [including 59 ducks and coots (*Fulica americana*)] and 4 mammals killed by one or more weasels (*Mustela frenata*) stranded on a small Lower Souris island. In later years, mink (*Mustela vison*), when present, usually preyed heavily upon nesting ducks and ducklings. Skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*), raccoons (*Procyon lotor*), foxes (*Vulpes fulva*), and crows were relatively efficient in excluding nesting from islands accessible to them.

During a late freeze on April 16, 17, and 18, 1953, a fox (or foxes) crossed about one-

fourth mile of new thin ice to reach Ding Island where they destroyed 11 of 12 active goose nests. In that year low water levels in Unit 326 permitted access to several islands. On these, all observed goose nests were destroyed.

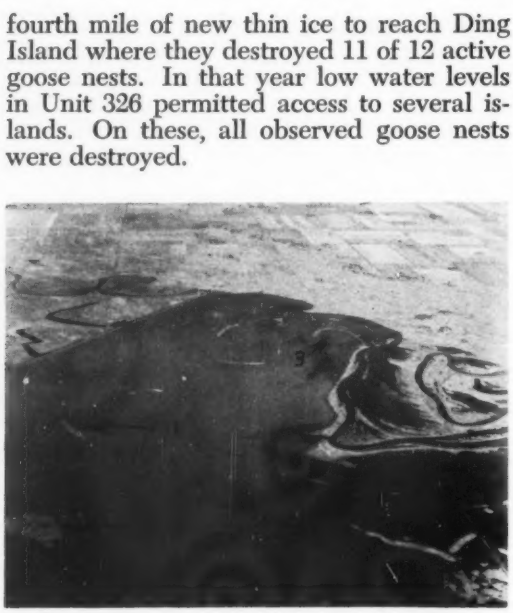


FIG. 1. Aerial view of Gadwall (1) and Ding (2) islands, Lower Souris Refuge. Islands close to bars or marsh (3) are accessible to predators and seldom have successful nesting.

While the nests of many colonial species are relatively secure as long as they are attended by the adults, when the latter are forced to leave their nests, the exposed eggs are subject to increased losses from gulls (*Larus* spp.) and crows. Under normal circumstances a pair of geese can successfully defend their nest against crows and the smaller mammals. We have had reported instances of geese driving crows away from the nest site and of a mallard hen defending its nest against an attack by crows.

Most large marshes in the Prairie States and Provinces probably support a wider variety and greater number of egg-eating mammals and birds than is found in many other agricultural districts of the continent. Since the recent drought (1930's), raccoons and foxes have increased and extended their ranges into all suitable habitat.

When nest predators are naturally in low numbers, or where intensive predator control is carried on, islands may not be of great importance. It appears, however, that the low rate of reproduction and heavy hunting pressure operating with geese require high nesting success if populations are to attain satisfactory levels in settled areas.

Colonial island-nesting birds, such as gulls, pelicans (*Pelecanus erythrorhynchos*), and cormorants (*Phalacrocorax auritus*) frequently prevent waterfowl from nesting. Leon Snyder (interview) described the regular desertion of nests by geese as soon as pelicans began nesting in numbers (Bowdoin National Wildlife Refuge, Malta, Montana). Goose nests at Lower Souris were usually near hatching by the time cormorants and great blue herons (*Ardea herodias*) began nesting, however. Duck nests are usually not found on the island used by nesting pelicans on Lacreek Refuge.

The losses that arise from increasing social tension as a nesting population builds up are often severe. Naylor (1953:90-91) describes an island 30 by 75 yards in dimensions, upon which 16 of 31 goose nests were deserted, mostly due to the overcrowded condition. Successful pairs often left the nest with two or three young and deserted the remaining eggs. Some of the nests were as close as 6 feet. Miller and Collins (1953:392) reported: "Desertion, the greatest factor causing nest failure in this study, was attributed mainly to intraspecific strife on heavily populated islands where competition for nest sites was acute. The desertion of nests on crowded islands amounted to 13 nests or 56.6 per cent of the total nests deserted."

Kossack (1950:638) observed 10 and 12 goose nests per acre on a 2.3-acre island in 1945 and 1946. "The shortest distance between nests was 40 feet and the longest 90 feet." Desertions accounted for 5 of 24 nests in 1945, ". . . because of floods, crows, or unknown reasons." In 1946, with 28 pairs ". . . one nest was broken up by a pair trying to reclaim their nest site of 1945, and one nest was deserted." He concluded that, except for these instances, the birds nested in harmony.

On mainland areas Johnson (1947:24) found that Canada geese should not be crowded beyond one-half or one acre per pair.

Only 4 of 94 Lower Souris goose nestings were deserted in 1951 and 1952 (some were 50 to 60 feet apart).

Over a period of time, geese will adjust to very close quarters, apparently depending upon the satisfactory establishment of the flock social order. Leading to this point, nestings separated by only short distances

seem to result in appreciable amounts of desertion.

With Lower Souris island duck-nesting concentrations, desertions amounted to 8 per cent (29 of 370 nests) during 1947 and 1953. Mainland rates for dabblers have regularly been 3 to 4 per cent or less. Accompanying the increased losses to this factor are layings by more than one hen in a single nest, successful incubation of only part of the multiple clutches, irregularities in incubation by some hens, and an increased incidence of dropped eggs.

Infertile eggs and dead embryos comprised 16 per cent of the total eggs in a sample of 90 terminated island gadwall nests examined by Hammond and L. J. Harrison, August 1, 1947. A three-year average (1938 to 1940) for 934 eggs was only 4.8 per cent for unhatched eggs in successful mainland nests.

The absence of predation on Lower Souris islands isolated by open water has led to some exceptional duck-nest densities. On islands averaging 0.3 to 1.0 acre in size, there have regularly been 20 to 80 nests per acre.

Gadwall Island (0.8 acre), with at least 160 nesting pairs in 1947, exceeded a rate of 200 nests per acre (Henry, 1948). About 90 per cent of the nests hatched, and 1,350 young were produced. This rate of hatching success has usually been equaled by both ducks and geese on all of the open-water islands. Averages for mainland nest samples have rarely exceeded 50 per cent in recent years.

Flooding and erosion in 1949 caused many ducks to move from Gadwall to Ding Island, 500 yards south. Since that time the nesting population has been reduced to about 40 to 60 pairs.

Ding Island, a 7.0-acre natural area, maintained a population of about 100 nesting pairs or more through 1949 to 1955. Many pintails and mallards, as well as gadwalls, have nested upon it.

Gadwall clutch sizes were higher for island than for mainland nests (10.5 as compared with 9.2 for a six-year average, 1935-1940, for 200 nests). This may arise from either (1) the absence of loss of partial clutches to predators, (2) the addition of eggs by hens other than the rightful owner, (3) fewer renestings because of the higher nesting success on islands (Sowls, 1949: 263, shows that first clutches contain more eggs, on the average, than renestings), or (4) a true increase in clutch size. We tried to exclude from the tabulation all clutches known to have been laid by two or more hens in a single nest.

### ISLAND NESTING AND DRAINAGE

The question has been raised: "Do not the island-nesting concentrations observed in certain large marshes indicate that the number of small water areas might be greatly reduced by widespread agricultural drainage, yet by crowding provide an equal waterfowl population?"

While this may seem, at first glance, to be an absurd question, it is true that we do not know the limits to crowding in waterfowl populations. The breeding concentration at Mývatn (Scott, 1952:129) is of interest: "... The farmers of the nineteen farms round the lake ... take all eggs in excess of four from each nest. They have been doing this for about 700 years and figures for the egg-crop over the last fifty years show no overall decline. . ." It would appear that predation must be of very minor importance there. Considering waterfowl behavior alone, it is likely that breeding densities could be increased somewhat above present and recent population levels.

The territorial and nesting aspects of islands are not comparable to those of pothole and slough environment, however. Concentrations on land masses are extremely vulnerable to predation and to the various types of land use employed by our farmers and ranchers. Normally, we may expect that the greatest dispersal of nests into the widest variety of nesting habitat will insure the best survival.

Even the island concentrations are subject to catastrophic losses. Except under management or natural conditions, which exclude predation, flooding and other major decimating factors, they are not apt to continue uninterrupted over a long period of years.

In the light of our present knowledge we must conclude that reduction in habitat will result in proportionate declines in the waterfowl population.

### ISLAND CONSTRUCTION

The initial island construction on Lower Souris was completed prior to first flooding

of the marshes. Widths varied from 20 to 100 feet and lengths from 20 feet to nearly a mile. Earth was moved from each side to the center making a borrow pit or ditch that served to hold water for nesting ducks during years when impoundments were partly dry. The height above the surrounding bottom flats averaged four to six feet, but this was reduced in some cases by later settling and erosion.

In October 1955, a private contractor furnished D-7 bulldozer and operator for $10.00 an hour. In 48 working hours an island was constructed having a top surface 27 ft. by 264 ft. in dimensions, 6 ft. high with a slope of 1:7. Cost per cubic yard was about $0.12 (a total of 4,020 cu. yds.), and per running foot, $1.82. Costs for dragline construction would be somewhat higher, depending upon size of equipment and operating conditions.

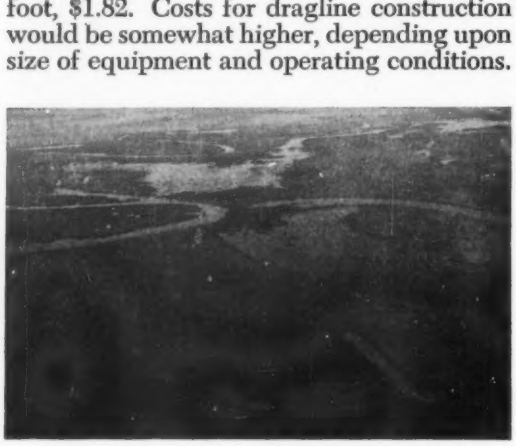


FIG. 2. Some "push-ups" built with bulldozer in 1953. These small islands in emergent vegetation can be built for $10.00 to $30.00, depending upon size.

We believe that this island could easily last 100 years and could average five goose nests each year. This figures out at about $0.20 for each goose produced. If nesting ducks are considered, the cost of $5.00 a year should produce about 100 ducks in addition to 20 geese.

After 14 years of flooding, the more exposed "dragline" islands have had an estimated surface loss of about 65 to 75 per cent due to waves and ice movement. To reduce future erosion, projects in 1953 and 1955 were planned so that each island would be protected from waves by other islands, dikes, or natural windbreaks. We believe that close spacing will prolong the life of the development, hold down construction costs, and provide for greatest waterfowl use per acre of impounded area. There are further economies in use of bulldozers to push up small islands suitable for a single goose pair in such protected areas. Ray Erickson (interview) reported immediate acceptance of them as goose nesting sites on Malheur Refuge, Oregon. He found that they should be higher than the surrounding marsh cover and should be constructed in pairs a few hundred feet apart to provide for both nest and a lookout stand for the male. About 18 inches of water was believed desirable to reduce access by predatory animals.

We have also built a few of these "push-ups" in isolated patches of emergent vegetation. One of the more attractive of them was used in 1956.

On some projects log booms or stone riprap may be needed to hold light soils in place. Scattered stands of emergents probably do not detract and would be of value as wave barriers.

It is usually important that islands be separated from the mainland by at least several hundred feet of open water if they are to remain predator free. Even then they should be inspected each spring to remove animals that may have moved onto them during the winter. We have not seen any tendency for concentrated island duck nesting on any marginal or shallow marshy locations. Raccoons and coyotes were observed to cross channels of 100 feet and less. Skunks and foxes are not barred by deep channels 20 feet in width.

In shallow marshes sufficient isolation through the goose nesting season may be obtained if a belt of vegetation 200 to 300 feet wide can be removed from around the island. This may be done through burning or mechanical means when water levels permit.

Water depth is undoubtedly of considerable importance; raccoons and most animals will probably wade greater distances than they will swim. Twelve to 18 inches of water seems to be a desired range, considering both isolation and damage from waves. In deeper waters the island height must be increased to compensate for increased erosion and to provide freeboard. Pondweeds provide effective protection during several months of each year; they are usually in better stands in the shallower waters.

Size and shape are of importance chiefly

with regard to diminishing returns as certain limits are exceeded. Islands with surfaces 15 to 30 feet wide will usually have more use, per acre, than those much larger.

The proximity of food may be of greater importance to ducks than to geese. All of the favored Lower Souris gadwall island concentrations were in sites having an abundance of pondweeds. Geese nest prior to pondweed development and sometimes fly a mile to feeding sites in grain fields or flooded meadows.

While we have several graveled islands under observation, we cannot see that they have been disproportionately selected. In marshes lacking grit they would serve as a good source of supply, and this may favor heavier nesting use. Gravel will also aid in stabilizing the slopes and binding silt and muck materials thrown up in island construction.

FIG. 3. A close view of Gadwall Island in 1947. At this time there were at least 160 ducks and a colony of common terns (*Sterna hirundo*) nesting upon it. (Photo by C. J. Henry)

In the past, small brush-hay mounds and elevated tubs (Yocom, 1952) have been placed in the marsh. Up to the present time they have not been used, but we feel that further trials of nesting devices of this type should be made because of their low cost.

We did not observe any use of muskrat houses for nesting until 1956. The two nests found that spring suggest that the importance of these sites may increase in future years.

There are decided advantages in planning for and completing island construction during the early development of any impoundment. Equipment would be on the spot and dry working conditions would favor relatively low costs. Many water areas, unproductive because of their shoreline type, could support important breeding goose populations if islands could be provided.

## SUMMARY

Nesting islands play an important role in the production rates of certain populations of Canada geese, and locally of some ducks.

Waterfowl quickly learn to take advantage of predator-free nesting sites such as islands. Other factors favoring heavy island use are the high ratio of water-land edge to land mass and the close proximity of water, food, loafing sites, and nesting cover. Concentrations arise through good annual survival and probably the social attractions of breeding displays. Vegetation is of minor importance as a nesting factor, unless it becomes too tall and rank. Gadwalls and mallards do choose the denser growth of weeds if they are available. The principal island-nesting losses are due to predation, competition of other birds, and intraspecific strife. Lesser losses arise through irregularities in laying and incubation by some hens under crowded conditions.

On the Lower Souris refuge only the islands well surrounded by open water have been particularly attractive and have had high nesting success. They are believed to be primarily responsible for the build-up of a resident Canada goose flock from 22 to about 370 birds between 1937 and 1954, despite a severe set-back in 1945. In 1954 only about 50 to 60 feet separated nesting pairs on some islands, and closer crowding will probably result in increased friction and nest loss. In the gadwall-nesting concentrations (which reached a rate of 200 nests per acre on one favored island), there are some pairs using the islands through the day. Other pairs, having part of their home ranges elsewhere, fly to the islands to nest, resulting in a great deal of aerial pursuit and other breeding displays. The "resident" drakes are not able to prevent the intruders from nesting.

We do not feel that the occurrence of island concentrations justifies the belief that waterfowl on mainland areas can make a similar adjustment if habitat is decreased through drainage. More likely, reduction in water areas will cause a proportionate decline in waterfowl populations. In new island construction the important considera-

tions are: (1) isolation from mainland areas by several hundred feet of open water at least 12 inches in depth; (2) control of erosion through close spacing, proximity to protective structures, treatment of margins with resistant materials, or use of natural vegetative wave breaks; and (3) a size apt to furnish the greatest waterfowl use for the money expended. Costs in 1955 were $1.82 a running foot for a large island constructed by bulldozer. With a life expectancy of 100 years this comes to about $0.20 for each goose and $0.05 for each duck we would expect to be produced.

## LITERATURE CITED


ARMSTRONG, E. A. 1947. Bird display and behaviour. Oxford Univ. Press. N. Y.

BENT, A. C. 1923. Life histories of North American wild fowl. U.S. Natl. Mus., Bull. 126.

——. 1925. Life histories of North American wild fowl. U.S. Natl. Mus., Bull. 130.

CRAIGHEAD, F. C., JR. AND J. J. CRAIGHEAD. 1949. Nesting Canada geese on the upper Snake River. J. Wildl. Mgmt., 13:51-64.

CRISSEY, W. F. AND OTHERS. 1951. Waterfowl populations and breeding conditions – summer 1951. U.S. Fish and Wildl. Service; Canadian Wildl. Service; Spec. Sci. Rept. Wildlife No. 13.

ERRINGTON, P. L. 1946. Predation and vertebrate populations. Quart. Rev. Biol., 21:144-177.

GROSS, A. O. 1945. The black duck nesting on the outer coastal islands of Maine. Auk, 62:620-622.

[HAMMOND, M. C.] 1950. Canadas in N. D. N. Dak. Outdoors, 12(11):6-7.

HENRY, C. J. 1948. Summer on the Souris marsh. Audubon Mag., 50:242-249.

JOHNSON, C. S. 1947. Canada goose management, Seney National Wildlife Refuge. J. Wildl. Mgmt., 11:21-24.

KALMBACH, E. R. 1937. Crow-waterfowl relationships. Circ. U.S. Dept. Agric., No. 433. 36 pp.

KOSSACK, C. W. 1950. Breeding habits of Canada geese under refuge conditions. Amer. Midl. Nat., 43:627-649.

MILLER, A. W. AND B. D. COLLINS. 1953. A nesting study of Canada geese on Tule Lake and Lower Klamath National Wildlife refuges, Siskiyou County, California. Calif. Fish and Game, 39:385-396.

——. 1954. A nesting study of ducks and coots on Tule Lake and Lower Klamath National Wildlife refuges. Calif. Fish and Game, 40:17-37.

NAYLOR, A. E. 1953. Production of the Canada goose on Honey Lake Refuge, Lassen County, California. Calif. Fish and Game, 39:83-94.

SCOTT, P. 1952. Mývatn 1951. Fifth Annual Report of the Severn Wildlife Trust, 1951-1952, pp. 125-132. Country Life Ltd., London.

SOWLS, L. K. 1949. A preliminary report on renesting in waterfowl. Trans. N. Amer. Wildl. Conf., 14:260-273.

WILLIAMS, C. S. AND WM. H. MARSHALL. 1938. Duck nesting studies, Bear River Migratory Bird Refuge, Utah, 1937. J. Wildl. Mgmt., 2:29-48.

—— AND OTHERS. 1948. Waterfowl populations and breeding conditions—summer 1948. U.S. Fish and Wildl. Service; Canadian Wildl. Service; Spec. Sci. Rept. No. 60.

—— AND ——. 1950. Waterfowl populations and breeding conditions—summer 1950. U.S. Fish and Wildl. Service; Dominion Wildl. Service; Spec Sci. Rept.: Wildlife No. 8.

YOCOM, C. F. 1952. Techniques used to increase nesting of Canada geese. J. Wildl. Mgmt., 16: 425-428.


Received for publication February 11, 1956.

## THE WILDLIFE SOCIETY
### NOMINATIONS FOR OFFICES—1957-58

*President* ..... A. Starker Leopold[1]
Winston W. Mair

*Vice-President* ..... Ben Glading
R. B. Miller

*Regional Representatives*

Region 1 ..... W. R. DeGarmo
Roger Latham

Region 2 ..... C. Edward Carlson[2]
E. B. Chamberlain

Region 3 ..... Bill T. Crawford
Don Douglass

Region 4 ..... Don C. Quimby[3]
Lee E. Yeager

Region 5 ..... Fred M. Baumgartner[4]
W. C. Glazener

Region 6 ..... J. B. Lauckhart
Charles F. Yocom[1]

Region 7 ..... R. Y. Edwards
C. D. Fowle

[1] In accordance with the Bylaws, Starker Leopold, nominated both for President and Regional Representative, will be listed on the election ballot for President only.

[2 3 4] Leonard E. Foote, Wendell G. Swank and Ralph R. Hill nominated as Regional Representatives for Regions 2, 4 and 5 respectively, declined nomination—Swank because he will be in Africa on a Fulbright Fellowship, and Foote and Hill because of previous nominations and other commitments including Society assignments.

# OBSERVATIONS ON FACTORS AFFECTING SMALLMOUTH BASS PRODUCTION IN IOWA

*Robert E. Cleary*

Iowa Conservation Commission, Independence, Iowa

Many states in the range of the northern smallmouth bass (*Micropterus d. dolomieui*) have in recent years conducted, or are at present conducting, studies on various factors in the life history of this species. Fleener (1952) in Missouri, and Larimore (1954) in Illinois, worked on the effect of artificial stocking; Gerking (1953) in Indiana, and Larimore (1952) in Illinois showed evidence of the homing instinct or behavior; and Webster (1953) worked out the patterns of dispersions and movement of the smallmouth bass in Cayuga Lake, New York.

In the streams of northeast Iowa, the smallmouth bass is considered a major fisheries resource. With the accelerated fishing tempo directed against this species in the last decade, the characteristic instability of stream populations of the smallmouth bass has become increasingly apparent. In 1949, a study of factors that could potentially influence natural reproduction and survival was begun. In addition, efforts were directed toward developing a simple method of censusing both the adult and the young-of-the-year segment of a stream population.

In 1949, a series of 17 representative smallmouth bass streams were chosen and annual checks of their production capabilities were begun at permanent survey sites. Streams that provide smallmouth bass fishing in Iowa follow no set pattern. Consequently, these survey streams were chosen to include all the characteristics present in the streams of this area. Turbidity at the time of the surveys ranged from readings of less than 8 inches to crystal clear, and bottoms from bedrock, sand and gravel to clay and silt. The streams ranged in length, size, and volume of flow from creeks less than 30 miles long and averaging less than 20 feet wide to streams more than 60 miles long and averaging 30 to 40 feet wide.

In a manner similar to the technique devised by Surber (1939), a representative mile of each stream was walked by a two-man party and nests were counted during the spawning period when and if visibility permitted (Table 1). Some streams had to be revisited as many as three times before the water was clear enough to permit accurate visual counts. In some streams (not included in Table 1) no count could be made during the entire spawning season because of turbid conditions.

TABLE 1. – NUMBER OF SMALLMOUTH BASS NESTS PER MILE OF STREAM, 1949-1953

| Stream | 1949 | 1950 | 1951 | 1952 | 1953 |
|---|---|---|---|---|---|
| Lime Creek | 9 | 21 | 29 | 30 | 24 |
| Bear Creek | 13 | 19 | 14 | 24 | 23 |
| Silver Creek | 8 | 8 | 13 | 15 | 7 |
| Pine Creek | 5 | 16 | 24 | 9 | 13 |
| Coffins Creek | 6 | 18 | 7 | 7 | 8 |
| Little Turkey River | 28 | 21 | 15 | 8 | 7 |
| Volga River | 38 | 41 | 46 | 48 | 53 |
| Averages | 15 | 21 | 21 | 20 | 19 |

Fingerling counts as an index to hatching success were made during the last week of July each year. While nest counts were made over a mile of stream, data on reproduction were secured by seining only 500 lineal feet of the same area with a 25-foot, quarter-inch mesh, modified bag seine. No effort was made to seine out every bass in the 500-foot area as it would have been virtually impossible in rocky or large streams. Harrison (1954), in a discussion on seining for smallmouth bass fingerlings in the Des Moines River system in western Iowa, arrived at a seining success of 29 per cent, using a visual count prior to seining. Our effectiveness in seining varied from a low of 14 per cent to a high of 100 per cent, but averaged from 20 to 25 per cent using a visual count before seining. Hence, the data secured gave only a relative index as to success or failure of the annual hatch. However, in each case the same area was covered, either visually while taking the nest counts or with the seine on the fingerling counts, to allow for comparable annual data.

The data for all tables and graphs are based on observations made in seven of the 17 test streams covered annually by the sur-

vey. These streams were chosen since the five-year data were complete in all respects and one or more years' data were lacking on other streams of the survey series. Precipitation data were abstracted from the April, May, and June issues of the U.S. Dept. of Commerce publication, "Climatological Data—Iowa," for the years 1949 through 1953. The recording station, or stations, nearest each survey site was used as the data source.

The following discussion of the factors that influence nesting will of necessity be limited to those that were visually obvious. As the survey progressed, it became apparent that the precipitation, water temperature, and stream morphology were among the most important factors.

A weir with an appended trap was placed approximately one mile above the mouth of one of these survey streams in 1949 and again in 1950. A concentrated movement of adult smallmouth bass into the feeder stream from the river occurred when the minimum daily water temperature was above 60° F. and in both years during this period there was a freshet of some consequence in the stream.

In two early papers on the breeding habits of the smallmouth bass, Reighard (1906) and Beeman (1924) concurred that spawning usually took place between 62° and 64° F., and nest building could start when the water was still in the 50's. Webster (1945) found bass spawning in ponds at 53° F., and bass spawning was noted in several instances in the survey streams at water temperatures below 60° F. Evidently, temperature thresholds for spawning are variable. It was also noticed in this series of survey streams that spawning was not a nearly simultaneous occurrence in all reaches as noted by Surber (1942). In the Iowa streams, the number of nests containing eggs or fry was never seen to exceed 60 per cent of the total, an indication of a prolonged spawning season. In Lime Creek, which was the "pilot" stream of the series, the beginning of spawning ranged from April 29 to May 12 in the five-year period.

The male smallmouth bass chooses its nest site with care, and may often construct two to three nests, until he finally settles on one as suitable. Nests were usually dished out down to coarse, egg-sized rubble; however, nests over bedrock were not uncommon. Exceptionally good sites were used year after year if they remained physically unaltered. Deep pools were not necessary for nesting sites, and most nests were constructed in less than 30 inches of water. Bass utilized the margins of deep pools seemingly to take advantage of the minimum current. They also sought out obstructions such as stumps, logs, stones, or cuts in the banks, and had a definite preference for overhead cover. Most, but not all, nests were on the downstream sides of these obstructions. In small, shallow pools most nests were found in the lower extremities if no obstructions to the current were present. The lack of minimum-velocity pools limited nesting in many areas of the survey streams. Stream straightening has rapidly become a definite threat to many smallmouth bass streams in prairie areas. Not only is the straightened area devoid of suitable nesting habitat, but the area immediately below is subjected to heavy silt deposition as a result of bank caveins.

A comparison of nest counts with the prenesting precipitation in watersheds in which counts were made is shown in Fig. 1. With the exception of the 1950 spring floods, the effects of which were still apparent but waning in 1953, prenesting precipitation appar-

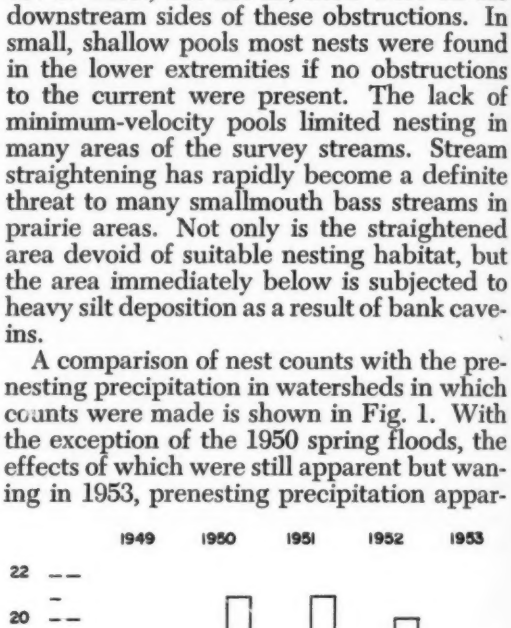



FIG. 1. Comparison of the number of smallmouth bass nests with the prenesting rainfall. The shaded areas indicate the rainfall in inches; the clear areas indicate the number of nests per mile of stream.

ently has no effect on the nesting utilization of a stream. It is believed that the newly created or rejuvenated pools formed by the 1950 floods accounted for the increased nesting during 1950 to 1953 as opposed to the belief that this increase was brought about by an enlargement of the adult or spawning segment of the smallmouth population of the area.

Actual data to support this contention are lacking. However, it is known, as will be shown later, that in years of heavy May and June rains, natural reproduction is poor. There were heavy spring rains in 1946 and 1947, and it is assumed that reproduction was low, while there was good reproduction in 1948 and 1949 when May and June were relatively dry. Since most male smallmouth bass spawn for the first time at a length of 8 to 10 inches, or at an age of four years, 1950 and 1951 should have been troughs in the nesting graph, and 1952 and 1953 should have been peaks. Since these peaks and troughs are not apparent in Fig. 1, it is strongly suspected that the number of nests per mile is more an index of the quality of nesting habitat than of the size of the spawning or adult population of smallmouth bass in a stream.

Turbidity did not seem to exert a direct influence on nesting. These was evidence that nesting, spawning, and hatching took place in these streams during sporadic periods of turbidity. However, streams that remained turbid for long periods of time, due to heavy erosion in their watersheds, seldom produced either smallmouth bass fingerlings or good smallmouth bass fishing.

It is believed that the crux of the entire problem of smallmouth bass production depends on the ecological features that prevail during the postnesting period. As in nesting, a complex of various factors working singularly or in conjunction with one another, may definitely affect the number of eggs or fry that survive to fingerling size (Table 2).

Of singular importance to smallmouth bass production is the condition of a stream in regard to water stage during the critical postnesting period. Surber (1942), Starrett (1951), Allen (1951), and others have reported on the disastrous effects of flood waters on nests, eggs, and fry of various stream fish.

This postnesting period endures for some

TABLE 2.—NUMBER OF SMALLMOUTH BASS FINGERLINGS PER 500 FEET OF STREAM, 1949-1954

| Stream | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 |
|---|---|---|---|---|---|---|
| Lime Creek | 32 | 0 | 0 | 24 | 7 | 2 |
| Bear Creek | 20 | 0 | 2 | 23 | 10 | 4 |
| Silver Creek | 6 | 0 | 0 | 11 | 2 | 4 |
| Pine Creek | 13 | 0 | 0 | 35 | 3 | 11 |
| Coffins Creek | 3 | 0 | 0 | 8 | 4 | 6 |
| Little Turkey River | 10 | 0 | 0 | 2 | 14 | 5 |
| Volga River | 11 | 2 | 1 | 13 | 2 | 4 |
| Averages | 13.6 | 0.3 | 0.4 | 16.6 | 6.0 | 5.1 |

45 days after nest building and spawning, which take place usually during the first or second week in May in northeast Iowa. During this period, high water can tear out eggs or damage the fry either directly by causing physical injury, or indirectly by sweeping them almost entirely out of the "nursery" habitat.

Another disastrous feature of the flash floods is that following such a period the fry that survive may find it difficult to obtain adequate food. The molar action of flood waters often tears out portions of the food chain, especially the microcrustaceans that are so vital to fry that have just lost their yolk sac. In addition, the turbid conditions normal in postflood periods may inhibit the sight-feeding activities of the smallmouth bass fry. The dependency of smallmouth bass production on moderate rainfall, which in turn governs the water stages in the spawning areas, is shown in Fig. 2. During the years in which the average precipitation was less than seven inches during the postspawning period, hatching and survival were considered good.

In this postnesting period, temperature may also prove to be a limiting factor in production. Beeman (1924), Langlois (1931), and others have discussed the development or incubation threshold temperatures for the species. Under natural conditions, adverse temperatures, during and after spawning, may expose eggs or fry to vigorous climatic conditions by prolonging the critical developmental period. Webster (1945) and Jurgens and Brown (1954), working on smallmouth bass and largemouth bass (*Micropterus salmoides*), respectively, provided evidence that extreme and prolonged temperature drops are not necessarily the direct cause of egg mortality.

However, in 1953, a severe and prolonged

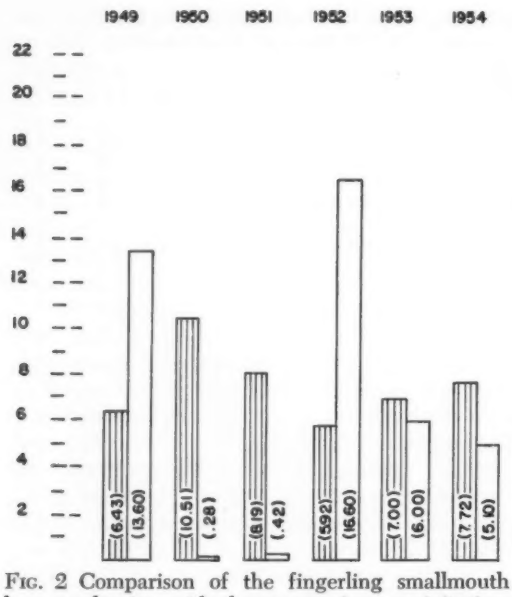



FIG. 2 Comparison of the fingerling smallmouth bass production with the postnesting precipitation. The shaded areas indicate the average precipitation in inches; the clear areas, the average number of fingerling bass in 500 feet of stream.

cold spell in northeastern Iowa, which occurred during the height of spawning, seemingly had an adverse effect on hatching and survival. Air temperatures dropped from 75° F. to 52° F. on May 12, and remained unseasonably low for the following ten days. On Lime Creek, a maximum-minimum thermometer, placed in a small pool having three nests that contained eggs, indicated that the minimum reading was never above 50° F., and the maximum reading never reached 60° F. The eggs became heavily infested with a fungus growth, and during the process seemingly lost some of their adhesiveness. On May 20, following a moderate (6-inch) stage rise of a two-day duration, all three nests were swept bare of eggs and, to all appearances, abandoned. Renesting began in the same pool on May 26. In some nests on other stretches of the same stream both fresh and fungused eggs were found in the same nest.

Fingerlings taken in July test-seining after this phenomenon were thought to have resulted from a second spawning that took place the last week in May and the first week of June, three weeks later than normal spawning dates for this area. In fact, a single group of smallmouth bass fingerlings that had an average total length of less than three-fourths inch, as compared to the normal size of two to two-and-one-half inches for this time of year, were taken in one of the test streams, indicating that spawning continued well into June. There was little range in total length apparent in the 1953 year class, with the exception of the exceedingly late hatch previously mentioned, indicating an almost complete loss of early spawned fish.

In 1952, there was almost as sharp a decline in water temperature, but this condition was of shorter duration and no apparent harm was done to the freshly deposited eggs. On May 7, the water temperature dropped from an average high of 68° F. to a maximum of 52° F. on Lime Creek. Four days later the maximum reading had reached 58° F. Spawning activities were then resumed on the 15th of May. Most streams had two length frequencies of fingerling smallmouth bass by the end of July.

Webster (*op.cit.*) stated: ". . . . that the presence or absence of the male bass appears to bear little relation to the numbers of dead eggs, the degree of fungus infestation, or to the amount of silt deposited on the nest." The writer is inclined to agree with these observations on the importance of parental care to smallmouth bass production. Since most of the descriptions of the early life history were made from observations of confined or hatchery fish (Reighard, and Beeman—*op.cit.*), the territorial or nesting behavior of the male fish may have been intensified under artificial situations. In our nesting surveys, the male bass kept the nest "fanned" and "bright" only until the eggs were deposited. At that time a fine layer of silt was allowed to cover both eggs and nest, making it almost indistinguishable from the normal bottom. Inasmuch as aeration of eggs is not necessary in flowing water, nesting territory was still patrolled and the male only occasionally hovered over the nest. However, the male bass then became definitely secretive and was very seldom seen unless driven from some adjacent cover area. Never was the male bass seen herding or even attending the newly hatched fry.

The ability to recoup, or in this case to renest, after natural calamities is an important feature in the perpetuation of many fish and game populations. Flash floods or prolonged periods of cold weather during the spawning

and nesting season usually stimulated a general bass renesting when conditions returned to normal. It was not determined what portion of this second nesting was actually a renesting of the original spawners, and what portion was a stimulated late nesting of bass spawning for their first time. Precipitation and corresponding stream rise usually attend these periods of abnormal low temperatures in the spring, and this rise may cause an influx of new bass which are still capable of spawning. These fish may move in from other areas of the tributary streams or, more likely, from the river receiving the tributary.

The nest counts on second nestings were usually greater than the first, and the nesting bass were of smaller average size. In 1953 and 1954, second or renesting counts were made on six streams after a freshet of some considerable degree. Undoubtedly some of the nests from the original count were still active after the flood; however, there was a 31 per cent average increase in the number of nests on the second count over the original count.

In reproduction counts there is usually evidence of recruitment from each successful nesting by the presence of two or even three length frequencies in fingerling smallmouth bass from the same stream.

It has long been the problem of the fisheries biologist to devise a technique that will, with some assurance, allow him to estimate the size of a stream fish population. The technique of nest counting apparently does not offer an index to the size of the adult population, but only to the quality of the nesting habitat. While angling in stream areas where nesting is high is usually productive, there is no apparent correlation between annual nesting intensity and angling success (Table 3).

TABLE 3. — COMPARISON BETWEEN SMALLMOUTH BASS NEST COUNTS AND ANGLING ON THE SAME STREAMS, 1951-1953

| | 1951 | 1952 | 1953 |
|---|---|---|---|
| Total bass taken | 55 | 141 | 173 |
| Number of hours fished | 102 | 306 | 313 |
| Number of bass per hour | 0.47 | 0.47 | 0.55 |
| Number of nests per mile | 0.21 | 0.20 | 0.19 |

The angling data used in Table 3 were obtained from a modified voluntary creel census that has been used for the last five years in northeastern Iowa. The data cover success and effort only on those seven streams treated in this discussion, which accounts for the low number of angling hours. In addition, there is seemingly no correlation between nest counts and the number of eggs or fry that survive to fingerling stage (Fig. 3). Smallmouth bass production is too dependent upon unstable climatic factors to base a production index on a preproduction survey.

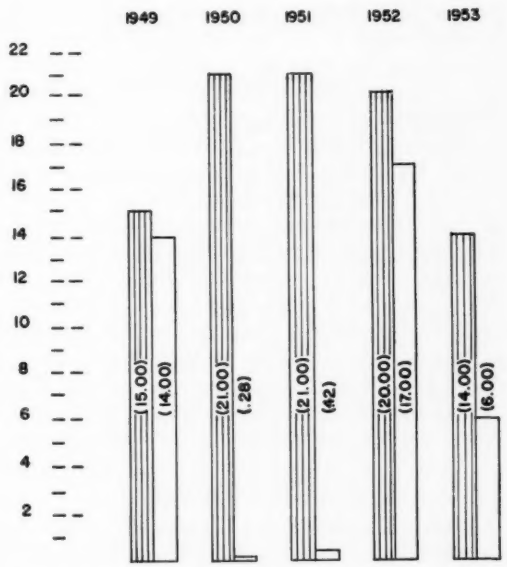



FIG. 3. Comparison of the nests per mile with the production of smallmouth bass fingerlings. The shaded areas indicate the average number of nests per mile; the clear areas, the average number of fingerlings in 500 feet of stream.

Since the nest counts failed to produce reliable indices to fluctuations in smallmouth bass populations, we had no way of checking the value of our seining technique. It may give a reasonably accurate picture of the year's reproduction; however, this technique does not offer a method of checking the effect of a given year class on future years' populations. This could be obtained only through an annual year-class analysis of scale collections. Observations on the number of subadult bass (6 to 8 inch) in streams show peak years in 1950 and 1954. Year-class analyses indicated that the good hatches of 1948 and 1952 survived to that stage.

A directed management plan is greatly handicapped by the fact that many of the factors that limit smallmouth bass production are beyond human manipulation. Watershed control and sound land management will definitely help; however, stream-improvement devices placed in streams having a sand bottom, as found in most smallmouth bass streams in prairie areas, usually have a relatively short and ineffectual life. Remedial stocking during years of poor natural production should benefit a reduced seed stock, but hatcheries would be at a production disadvantage to balance a poor natural hatch in a state's smallmouth waters. If we use the five-year seining average of seven fingerlings per 500 feet of stream, then 75 fingerlings per mile of stream is the seine-evident production. However, we have found by using a preseining visual count, that our seining efficiency varied between 20 and 25 per cent of the actual numbers. If we then apply this correction to our seining average, we may assume that the normal production of our test streams falls between 300 and 375 fingerling bass per mile. When a state's smallmouth bass water runs into hundreds of miles, this creates quite a production demand on the hatchery during a year when natural reproduction is extremely low.

## ACKNOWLEDGMENTS

The author wishes to express his appreciation to Paul A. and Fred J. Pierce, Iowa Conservation Commission, for assistance with the field work; and to E. B. Speaker, Iowa Conservation Commission, Dr. K. D. Carlander, Iowa State College, and Dr. Edward S. Deevey, Yale University, for suggestions in the preparation of the manuscript.

## SUMMARY

Nests counts and seine hauls for fingerlings were made on a series of smallmouth streams in northeastern Iowa during the years 1949-1954. Factors such as temperature, habitat, and turbidity are discussed as to their effect on smallmouth nesting. Prenesting precipitation in the watershed and subsequent changes in stream stage had no apparent effect on smallmouth nesting. Year-class strength in brood smallmouth as manifest by highs and lows in nest counts was not apparent. Nest counts are thought to be simply an index to the quality of the nesting habitat of the area surveyed. During years in which the average precipitation in the watershed was less than seven inches for a 45-day postnesting period, smallmouth hatching and survival were considered good. Prolonged periods of low temperature during the spawning season works a disadvantage to successful reproduction. The presence or absence of parental care has seemingly no effect on smallmouth production with the possible exception of an egg-predation preventative. There was no apparent correlation between annual nesting intensity and angling success. There was no correlation between nest counts and the resulting number of fingerlings on a given series of streams. It was calculated that the normal smallmouth bass production for the survey ranged between 300 and 375 per mile.

## LITERATURE CITED

ALLEN, K. RADWAY. 1951. The Horokiwi Stream, a study of a trout population. New Zealand Marine Dept. Fish. Bull. No. 10:1-231.

BEEMAN, H. W. 1924. Habits and propagation of the small-mouthed black bass. Trans. Am. Fish. Soc., 54:92-107.

FLEENER, GEORGE G. 1952. An intensive creel census of two similar smallmouth bass streams in the Missouri Ozarks. 14th Midwest Wildl. Conf., 11pp. (mimeo.).

GERKING, SHELBY D. 1953. Evidence for the concepts of home range and territory in stream fishes. Ecology, 34 (2):347-365.

HARRISON, HARRY M. 1954. Smallmouth bass studies—Des Moines River. Iowa Conserv. Comm. Qt. Biol. Repts., 5(4):6-11 (mimeo.).

JURGENS, KENNETH C., AND WILLIAM E. BROWN. 1954. Chilling the eggs of the large-mouth bass. Progr. Fish. Cult.. 16(4):172-175.

LANGLOIS, T. H. 1931. The problem of efficient management of hatcheries used in the production of pond fishes. Trans. Am. Fish. Soc., 61: 106-115.

LARIMORE, R. WELDON. 1952. Home pools and homing behavior of smallmouth black bass in Jordan Creek. Ill. Nat. Hist. Surv., Biol. Notes, 28:1-12.

——. 1954. Dispersal, growth, and influence of smallmouth bass stocked in a warm-water stream. J. Wildlife Mgmt., 18(2):207-216.

REIGHARD, J. E. 1906. The breeding habits, development, and propagation of the black bass. 16th Bien. Rept. Mich. State Bd. Fish. Comm. 1906 (Append.), pp.1-73.

STARRETT, WILLIAM C. 1951. Some factors affecting the abundance of minnows in the Des Moines River, Iowa. Ecology, 31(1):13-27.

SURBER, EUGENE W. 1939. A comparison of four eastern bass streams. Trans. Am. Fish. Soc., 68: 322-335.

——. 1942. Observations on the natural and artificial propagation of the smallmouth black bass, *Micropterus dolomieu*. Trans. Am. Fish. Soc., 72:233-245.

WEBSTER, DWIGHT A. 1945. Relation of temperature to survival and incubation of the eggs of smallmouth bass (*Micropterus dolomieu*). Trans. Am. Fish. Soc., 75:43-47.

——. 1953. Smallmouth bass, *Micropterus dolomieui*, in Cayuga Lake. Mem. Cornell Univ. Agric. Exp. Sta., 327:1-39.

Received for publication October 10, 1955.

# CHEMICAL COMPOSITION OF HERBAGE BROWSED BY DEER IN TWO WILDLIFE MANAGEMENT AREAS[1]

*Frank H. Smith, Kenneth C. Beeson, and Walter E. Price*

Department of Animal Industry, North Carolina Agricultural Experiment Station, Raleigh; U.S. Plant, Soils and Nutrition Laboratory, Agricultural Research Service, Ithaca, New York; North Carolina Wildlife Resources Commission, Raleigh (respectively)

White-tailed deer, *Odocoileus virginianus* ssp., in western North Carolina are a heterogeneous mixture of several subspecies, including *Odocoileus virginianus osceola* (Bangs) from Florida, *O. v. borealis* Miller from New York, as well as the native stock *O. v. virginianus* (Zimmerman), according to Ruff (1938). A number of *O. v. borealis* Miller from Wisconsin have been stocked since Ruff's report. These deer are not only larger but also are more thrifty and numerous than those, *O. v. virginianus*, in the Holly Shelter Wildlife Management Area located in the southeastern part of the state. The causes for the differences noted, other than size attributable to crossing, have not been identified. Notwithstanding an abundant supply of browse in the latter area (Barkalow, 1942; Wells, 1946), the number of deer taken during the hunting seasons has been relatively small and has continually declined. Forty-four deer were taken in 1941 and only 8 in 1952, even though the area was closed for hunting from 1944 through 1946.

Among possible factors that could prevent an increase in the population of the deer are: (a) predators, (b) diseases, (c) poachers, and (d) reproductive failures. The importance of the first two factors may be minimized because their effects have not been observed by the managers of the area except for an outbreak of disease in 1949 (Cox, 1950; Ruff, 1950). Some poaching has occurred, but this has been largely eliminated through improved patrol. The fourth factor may be related to the state of nutrition of the deer since an adequate diet is necessary for satisfactory reproduction (Maynard, 1951; Morrison, 1945). Wells (1946), referring to the Holly Shelter Area, suggested that the response of deer to calcium and phosphorus supplementation be studied under controlled conditions and, if positive effects were obtained, the required minerals be provided.

Previous studies on the nutrition of the deer have been carried out either by feeding trials with captive deer or by chemical analysis of the forage upon which they subsist.

Nichol (1938), using mule deer (*O. hemionus*) and white-tailed deer and hybrids of these in feeding trials, found the daily maintenance requirements per 100 pounds live weight of the deer were supplied by either about 2.2 pounds of a mixture composed of equal parts of grain and alfalfa leaves or very nearly that amount of forage (air-dry basis) native to Arizona. An intake of about 2.35 pounds of either grain and alfalfa leaves or

[1] This investigation was partially supported by funds provided under the Pittman-Robertson Act for Federal Aid in Wildlife Restoration. The samples from the Standing Indian Management Area were collected by Malcolm Edwards of the North Carolina Wildlife Resources Commission. The data were statistically analyzed by W. W. G. Smart, Jr.

Published with the approval of the director of the North Carolina Agricultural Experiment Station as paper No. 682 of the Journal Series.

native forage per 100 pounds live weight met their need for growth, gestation, and lactation.

French, *et al.* (1955), studying the nutritive requirements of the white-tailed deer, found that growth performance indicated a requirement of 3 to 4 pounds per day of good quality air-dry feed for a deer weighing 100 pounds. For optimum growth the diet should contain 13 to 16 per cent protein. The requirements for calcium and phosphorus in the diet were found to be in excess of 0.09 per cent and 0.25 per cent, respectively.

Feeding studies have indicated marked differences in the capacity of various forage species to supply the nutrients required by deer (Davenport, 1939; Forbes, *et al.*, 1941; Hagen, 1953; Maynard, *et al.*, 1935; Nichol, 1938). The response of deer to tests with a single species of browse has indicated in many instances that the nutritive requirements of deer generally have not been supplied by the amount consumed (Davenport, 1939; Maynard, *et al.*, 1935). It is possible that deer in their natural habitat meet these requirements by browsing a variety of species.

Many species of deer browse have been subjected to analysis in order to appraise their nutritive value in terms of their chemical constituents (Davenport, 1939; Einarsen, 1946; Gordon and Sampson, 1939; Hagen, 1953; Hellmers, 1940; Swift, 1948). The results have shown that the nutrients in a species vary with the stage of growth and the season of the year. In spring and early summer the crude protein is high and the crude fiber low. The former decreases while the latter increases as the seasons pass through summer into fall and winter (Einarsen, 1946; Gordon and Sampson, 1939; Hagen, 1953; Hellmers, 1940). These changes indicate a lowering of the nutritive quality of the browse as it matures and as winter progresses. The results from the determinations of the chemical composition of the deer browse in other regions suggested the application of this procedure to browse from the Holly Shelter Wildlife Management Area for the purpose of estimating the adequacy or deficiency of nutrients for deer.

## EXPERIMENTAL

A study was conducted in two stages. The first, initiated by the Wildlife Resources Commission, was undertaken to evaluate by chemical analysis the feed value of the browse from the Holly Shelter Area. In stage I of this study, the first collection of browse samples was made in November and December of 1946 from the species of plants the deer were known to consume. A sample of each species, representative of the portions of plants eaten (*i.e.* leaves and tender terminal twigs), was collected randomly from each of subareas A, B and C, dried and then analyzed for the usual constituents determined in proximate analysis as well as for calcium and phosphorus. Other collections were made in May-June and September, 1947, and in February, 1948. The results from the analyses indicated the need for a more intensive study.

The study was revised in 1949, stage II. Analyses were extended to include micronutrients and samples were collected from two contrasting areas, Holly Shelter, the trouble area, and Standing Indian, the area that supports deer of normal size, weight, and herd composition.

The Holly Shelter Wildlife Management Area is unsuitable for agricultural use since about 80 per cent consists of a peat bog covered with a dense vegetation of shrubs and vines, while the remainder is upland wire-grass savannas, some sand ridges, and a small wooded area along the Northeast Cape Fear River. The Standing Indian Wildlife Management Area in the Pisgah National Forest is located in Macon County in the mountains of western North Carolina. This area is heavily timbered and has a rough and stony terrain and numerous mountain streams.

Each management area was divided into four subareas, A, B, C, and D, from each of which a sample of the selected browse species was taken for analysis during each season. At Holly Shelter it was possible to select browse species that were available throughout the year but this was impossible at Standing Indian, because those species supplying the bulk of the diet for deer in spring and summer were dormant in winter. Moreover, the plant species at Holly Shelter were not available in the Standing Indian area due to climatic differences. Therefore, it was necessary to change the species sampled to correspond to those consumed by the deer in the respective seasons.

The samples were analyzed for the constituents determined in proximate analysis

by the Official and Tentative Methods of the Association of Official Agricultural Chemists (1945), calcium was determined by the McCrudden method as modified by Halverson and Schulz (1920), phosphorus by the method of Koenig and Johnson (1942), and iron, manganese, copper, and cobalt by the method of Parks, *et al.* (1943).

## RESULTS

The botanical species and the averaged chemical composition for the browse samples collected in subareas A, B, and C in the course of stage I between November 1946 and February 1948 are shown in Table I. The crude protein content of all species was less than 10 per cent except during the spring of the year. The crude fat and the nitrogen-free extract were higher than encountered in most forages, while the crude fiber of certain species was low. Calcium was found in moderate amounts in all species except *Carex*. Phosphorus was generally low in certain species at all sampling periods, while other species were high in the spring.

TABLE I. – CHEMICAL COMPOSITION[1] (DRY BASIS) OF BROWSE FROM HOLLY SHELTER WILDLIFE MANAGEMENT AREA DURING STAGE I

| Species[2] | Percentages at Time Sampled | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Spring May, '47 | Late Summer Sept., '47 | Fall Nov.-Dec., '46 | Winter Feb., '48 | Spring May, '47 | Late Summer Sept., '47 | Fall Nov.-Dec., '46 | Winter Feb., '48 |
| | Ash | | | | Nitrogen-free Extract | | | |
| *Smilax laurifolia* | 5.00 | 3.95 | 3.78 | 3.18 | 57.16 | 57.53 | 55.94 | 62.78 |
| *Ilex glabra* | 2.75 | 2.14 | 2.40 | 2.45 | 72.36 | 70.29 | 71.92 | 71.45 |
| *Cyrilla racemiflora* | 4.29 | 2.53 | 3.00 | 2.85 | 51.42 | 58.70 | 61.01 | 63.50 |
| *Myrica cerifera* | — | 4.67 | 3.75 | 4.12 | — | 56.35 | 60.15 | 60.49 |
| *Vaccinium crassifolium* | 5.60 | 4.48 | 4.08 | 4.64 | 61.35 | 60.06 | 60.84 | 62.33 |
| *Carex* sp. | 5.73 | 4.85 | — | 5.73 | 48.15 | 49.89 | — | 51.30 |
| *Persea* sp. | 4.07[3] | 2.72[3] | — | 2.84 | 51.16 | 46.65 | — | 53.30 |
| *Pinus* sp. | — | — | — | 2.17 | — | — | — | 48.44 |
| | Crude Protein | | | | Calcium | | | |
| *Smilax laurifolia* | 16.13 | 9.06 | 9.38 | 7.81 | 0.650 | 0.898 | 0.737 | 0.593 |
| *Ilex glabra* | 7.77 | 6.69 | 6.10 | 6.16 | 0.549 | 0.504 | 0.546 | 0.629 |
| *Cyrilla racemiflora* | 19.44 | 9.09 | 8.67 | 7.48 | 0.585 | 0.559 | 0.490 | 0.624 |
| *Myrica cerifera* | — | 9.54 | 9.76 | 9.51 | — | 1.238 | 1.076 | 1.232 |
| *Vaccinium crassifolium* | 7.38 | 6.18 | 6.46 | 5.78 | 0.684 | 0.807 | 0.993 | 0.890 |
| *Carex* sp. | 12.87 | 7.87 | — | 6.14 | 0.243 | 0.267 | — | 0.261 |
| *Persea* sp. | 13.92 | 10.09 | — | 8.88 | 0.516 | 0.488 | — | 0.608 |
| *Pinus* sp. | — | — | — | 2.42 | — | — | — | 0.460 |
| | Crude Fat | | | | Phosphorus | | | |
| *Smilax laurifolia* | 2.09 | 2.61 | 3.07 | 2.47 | 0.235 | 0.052 | 0.061 | 0.076 |
| *Ilex glabra* | 6.30 | 6.49 | 7.66 | 6.67 | 0.080 | 0.043 | 0.038 | 0.058 |
| *Cyrilla racemiflora* | 5.55 | 5.16 | 6.00 | 6.32 | 0.238– | 0.046 | 0.050 | 0.060 |
| *Myrica cerifera* | — | 8.37 | 8.29 | 6.26 | — | 0.026 | 0.017 | 0.021 |
| *Vaccinium crassifolium* | 3.33 | 5.93 | 6.59 | 6.49 | 0.090 | 0.047 | 0.050 | 0.059 |
| *Carex* sp. | 2.00 | 3.38 | — | 2.43 | 0.116 | 0.048 | — | 0.052 |
| *Persea* sp. | 2.83 | 5.44 | — | 4.79 | 0.204 | 0.067 | — | 0.033 |
| *Pinus* sp. | — | — | — | 7.24 | — | — | — | 0.011 |
| | Crude Fiber | | | | | | | |
| *Smilax laurifolia* | 18.13 | 27.19 | 26.46 | 23.54 | | | | |
| *Ilex glabra* | 10.72 | 14.54 | 11.92 | 13.27 | | | | |
| *Cyrilla racemiflora* | 19.24 | 24.17 | 21.15 | 19.68 | | | | |
| *Myrica cerifera* | — | 20.51 | 17.95 | 19.56 | | | | |
| *Vaccinium crassifolium* | 22.28 | 22.34 | 22.00 | 20.77 | | | | |
| *Carex* sp. | 31.59 | 34.02 | — | 34.06 | | | | |
| *Persea* sp. | 27.74 | 35.16 | — | 30.20 | | | | |
| *Pinus* sp. | — | — | — | 39.70 | | | | |

[1] Averaged for samples from subareas A, B, and C: one sample of each species from each subarea per season.

[2] Vernacular names are greenbrier, inkberry, swamp iron wood, wax-myrtle, blueberry, sedge, red bay, and pine respectively.

[3] Samples from subareas A and B only in May and September.

Mean values (one sample of each species from subareas A, B, C, and D respectively) for the composition of browse collected in stage II of this study are presented in tables 2 and 3.

The data were analyzed statistically to determine if there were differences between subareas, seasons, or species. Crude protein and phosphorus were the only nutrients that varied significantly among subareas A, B, C, and D at Holly Shelter. When data for all species were averaged for each area for the spring season, the percentage of protein and of phosphorus, respectively, ranged from 11.76 to 15.10 and from 0.144 to 0.215. Significant subarea differences in crude protein also occurred in the other seasons except winter; however, the average for all species per subarea and season, excluding spring, ranged from a high of 8.18 per cent in the fall to a low of 7.11 per cent in the winter. Significant differences of phosphorus content between subareas occurred in spring and in summer only. The average phosphorus for all species per subarea and season, excluding spring, ranged from a low of 0.039

TABLE 2. — CHEMICAL COMPOSITION[1] (DRY BASIS) OF BROWSE FROM HOLLY SHELTER WILDLIFE MANAGEMENT AREA DURING STAGE II

| | Macroconstituents | | | | Mineral Constituents | | | |
|---|---|---|---|---|---|---|---|---|
| Species[2] | Spring May, '49 | Summer Aug., '49 | Fall Oct.-Nov.,'49 | Late Winter March, '50 | Spring May, '49 | Summer Aug., '49 | Fall Oct.-Nov.,'49 | Late Winter March, '50 |
| | Ash, Per Cent | | | | Calcium, Per Cent | | | |
| *Smilax laurifolia* | 7.16 | 2.89 | 3.13 | 3.14 | 0.561 | 0.449 | 0.624 | 0.662 |
| *Ilex glabra* | 3.53 | 2.29 | 2.39 | 2.58 | 0.330 | 0.442 | 0.523 | 0.616 |
| *Cyrilla racemiflora* | 3.18 | 2.35 | 2.71 | 2.48 | 0.282 | 0.427 | 0.442 | 0.539 |
| *Myrica cerifera* | 4.14 | 4.83 | 4.62 | 4.05 | 0.500 | 1.184 | 1.231 | 1.111 |
| *Vaccinium crassifolium* | 3.98 | 4.71 | 4.90 | 5.40 | 0.730 | 0.785 | 0.870 | 0.831 |
| | Crude Protein, Per Cent | | | | Phosphorus, Per Cent | | | |
| *Smilax laurifolia* | 24.48 | 8.61 | 8.74 | 8.57 | 0.427 | 0.054 | 0.063 | 0.069 |
| *Ilex glabra* | 10.37 | 6.77 | 6.79 | 6.06 | 0.136 | 0.042 | 0.054 | 0.055 |
| *Cyrilla racemiflora* | 14.08 | 8.41 | 8.78 | 7.71 | 0.168 | 0.044 | 0.060 | 0.052 |
| *Myrica cerifera* | 15.98 | 11.27 | 11.21 | 10.80 | 0.136 | 0.036 | 0.054 | 0.045 |
| *Vaccinium crassifolium* | 9.00 | 5.95 | 6.44 | 6.07 | 0.109 | 0.042 | 0.051 | 0.055 |
| | Crude Fat, Per Cent | | | | Iron, p.p.m. | | | |
| *Smilax laurifolia* | 1.75 | 2.05 | 4.00 | 5.01 | 62 | 28 | 74 | 44 |
| *Ilex glabra* | 6.66 | 5.42 | 7.21 | 10.75 | 114 | 44 | 38 | 50 |
| *Cyrilla racemiflora* | 4.91 | 5.74 | 8.31 | 8.00 | 115 | 41 | 38 | 47 |
| *Myrica cerifera* | 6.83 | 5.23 | 6.59 | 6.41 | 131 | 96 | 76 | 108 |
| *Vaccinium crassifolium* | 6.10 | 6.76 | 7.65 | 8.54 | 93 | 71 | 48 | 57 |
| | Crude Fiber, Per Cent | | | | Manganese, p.p.m. | | | |
| *Smilax laurifolia* | 12.68 | 28.07 | 23.27 | 23.40 | 55 | 63 | 62 | 109 |
| *Ilex glabra* | 8.46 | 12.58 | 11.91 | 11.85 | 162 | 147 | 142 | 258 |
| *Cyrilla racemiflora* | 14.25 | 20.96 | 18.75 | 20.38 | 109 | 89 | 121 | 278 |
| *Myrica cerifera* | 14.40 | 20.86 | 17.63 | 17.81 | 221 | 145 | 221 | 598 |
| *Vaccinium crassifolium* | 16.70 | 21.29 | 17.85 | 17.05 | 293 | 204 | 201 | 296 |
| | Nitrogen-free Extract, Per Cent | | | | Copper, p.p.m. | | | |
| *Smilax laurifolia* | 53.95 | 58.33 | 60.74 | 59.86 | 8.8 | 4.2 | 4.7 | 3.0 |
| *Ilex glabra* | 70.91 | 72.91 | 71.69 | 68.76 | 5.5 | 2.9 | 3.9 | 3.2 |
| *Cyrilla racemiflora* | 63.53 | 62.54 | 65.07 | 61.44 | 5.8 | 2.3 | 2.8 | 2.0 |
| *Myrica cerifera* | 58.63 | 57.83 | 60.06 | 60.93 | 3.8 | 2.4 | 1.5 | 1.6 |
| *Vaccinium crassifolium* | 64.21 | 63.96 | 63.14 | 62.94 | 5.7 | 4.0 | 4.1 | 2.9 |
| | | | | | Cobalt, p.p.m. | | | |
| *Smilax laurifolia* | —— | —— | —— | —— | 0.04 | 0.03 | 0.06 | 0.04 |
| *Ilex glabra* | —— | —— | —— | —— | 0.05 | 0.05 | 0.05 | 0.02 |
| *Cyrilla racemiflora* | —— | —— | —— | —— | 0.05 | 0.05 | 0.07 | 0.06 |
| *Myrica cerifera* | —— | —— | —— | —— | 0.06 | 0.06 | 0.05 | 0.03 |
| *Vaccinium crassifolium* | —— | —— | —— | —— | 0.03 | 0.06 | 0.07 | 0.04 |

[1] Averaged for samples from subareas A, B, C, and D; one sample from each subarea per season.

[2] Vernacular names are greenbrier, inkberry, swamp iron wood, wax-myrtle, and blueberry respectively.

to a high of 0.054 per cent, both extremes occurring in the summer season. At Standing Indian, differences between subareas were significant and highly significant (5 and 1 per cent levels), respectively, for calcium and for crude fat in the samples collected in the summer and significant for nitrogen-free extract in the samples collected in November. For the season when significant differences occurred, the maximum differences between areas, using the average for all species, were: for calcium 0.188, fat 1.33, and nitrogen-free extract 1.59 per cent.

There were significant differences between species at both management areas. Highly significant ($P \leq 0.01$) differences in ash, protein, fat, fiber, nitrogen-free extract, calcium, phosphorus, manganese, and copper were found between species at Holly Shelter. Species differences in iron and in cobalt were not significant at the 5 per cent level.

The browse data from Standing Indian could not be analyzed statistically to the same extent as those from Holly Shelter since the same species could not be collected for all seasons. Significant differences in composition were found, however, between species and between seasons. While these differences are of academic interest, the higher quality of the nutritive constituents in the Standing Indian browse is of far greater importance.

## DISCUSSION

The reproductive performance of domestic animals is related to the plane of nutrition to which the animals have been subjected (Maynard, 1951; Morrison, 1945). An inadequate intake of either energy, protein, calcium, phosphorus, cobalt (in case of ruminants), or vitamin A decreases their capacity for bearing normal young. There probably is more than one limiting nutritive factor in diets that are inadequate for satisfactory reproductive performance.

This discussion will be limited to the data collected at Holly Shelter for the more carefully planned stage II of this study since the

TABLE 3. — CHEMICAL COMPOSITION[1] (DRY BASIS) OF BROWSE FROM STANDING INDIAN WILDLIFE MANAGEMENT AREA DURING STAGE II

| Species | Percentages at Time Collected | | | | | | | P.P.M. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | Crude Protein | Crude Fat | Crude Fiber | N.F.E. | Ca | P | Fe | Mn | Cu | Co |
| | | | | | Summer (August), 1949 | | | | | | |
| *Smilax rotundifolia* (greenbrier) | 5.66 | 14.02 | 3.88 | 23.37 | 53.03 | 0.858 | 0.123 | 89 | 270 | 9.0 | 0.06 |
| *Cornus florida* (dogwood) | 9.09 | 11.87 | 6.04 | 14.79 | 58.38 | 2.581 | 0.143 | 57 | 40 | 5.1 | 0.13 |
| *Liriodendron tulipifera* (tulip poplar) | 8.85 | 16.09 | 3.37 | 19.44 | 52.07 | 2.098 | 0.159 | 65 | 169 | 9.3 | 0.04 |
| *Acer rubrum* (red maple) | 4.85 | 11.34 | 7.02 | 19.49 | 57.27 | 0.921 | 0.147 | 63 | 637 | 7.0 | 0.04 |
| *Oxydendrum arboreum* (sourwood) | 5.11 | 13.46 | 5.23 | 22.74 | 53.22 | 1.110 | 0.148 | 44 | 156 | 3.2 | 0.08 |
| | | | | | Fall (November), 1949 | | | | | | |
| *Smilax rotundifolia* (greenbrier) | 5.70 | 12.28 | 6.83 | 17.24 | 57.95 | 1.249 | 0.138 | 111 | 467 | 8.5 | 0.06 |
| *Pyrularia pubera* (buffalo-nut) | 5.15 | 9.52 | 3.56 | 36.67 | 45.09 | 1.196 | 0.145 | — | 261 | — | — |
| *Rubus* sp. (blackberry leaves) | 6.59 | 12.78 | 3.97 | 14.04 | 62.60 | 1.557 | 0.127 | 97 | 620 | 7.3 | 0.07 |
| *Kalmia latifolia* (mountain laurel) | 3.87 | 8.87 | 9.31 | 13.93 | 63.92 | 0.924 | 0.107 | 44 | 656 | 4.5 | 0.04 |
| *Rhododendron maximum* (rhododendron) | 5.00 | 6.39 | 6.45 | 20.68 | 61.47 | 1.360 | 0.082 | 41 | 649 | 4.0 | 0.06 |
| | | | | | Winter (February), 1950 | | | | | | |
| *Smilax rotundifolia* (greenbrier) | 5.64 | 13.77 | 4.53 | 18.08 | 57.99 | 1.108 | 0.163 | 66 | 692 | 8.6 | 0.05 |
| *Pyrularia pubera* (buffalo-nut) | 6.63 | 11.67 | 4.26 | 31.50 | 45.97 | 1.371 | 0.226 | 53 | 177 | 10.0 | 0.07 |
| *Leucothoë editorum* (doghobble) | 4.07 | 9.01 | 8.03 | 21.10 | 57.79 | 1.104 | 0.110 | 35 | 1125 | 4.8 | 0.06 |
| *Kalmia latifolia* (mountain laurel) | 3.20 | 8.38 | 9.02 | 15.88 | 63.52 | 1.018 | 0.097 | 41 | 682 | 3.7 | 0.05 |
| *Rhododendron maximum* (rhododendron) | 4.76 | 6.42 | 5.84 | 21.25 | 61.72 | 1.464 | 0.077 | 31 | 857 | 3.7 | 0.04 |
| | | | | | Spring (May), 1950 | | | | | | |
| *Smilax rotundifolia* (greenbrier) | 5.55 | 16.15 | 3.75 | 19.53 | 55.02 | 1.014 | 0.173 | — | 160 | — | — |
| *Betula lenta* (sweet birch) | 7.39 | 24.91 | 7.91 | 18.29 | 41.48 | 1.198 | 0.281 | — | 746 | — | — |
| *Acer rubrum* (red maple) | 5.49 | 23.46 | 3.41 | 16.18 | 51.47 | 0.757 | 0.348 | — | 346 | — | — |
| *Helleborus* (hellebore) | 18.60 | 14.07 | 5.37 | 26.22 | 39.01 | 2.005 | 0.121 | — | 158 | — | — |

[1] Averaged for samples from subareas A, B, C, and D; one sample of each species from each subarea per season.

data of stage I are in accord with the subsequent findings.

An examination of Table 3 shows, for the Standing Indian browse, with the exception of hellebore, an ash content similar to that of many forages, such as lespedeza (Morrison, 1945), used for domestic animals. The decline of the crude protein from spring to fall as each species matured is in agreement with the findings of other investigators (Einarsen, 1946; Gordon and Sampson, 1939; Hagen, 1953; Hellmers, 1940). The averages for all species were: 19.6, 13.4, 9.97, and 9.85 per cent crude protein for the respective seasons. With sufficient supply of browse available, these levels probably are adequate for deer. Mountain laurel, *Kalmia latifolia,* and rhododendron, *Rhododendron maximum,* were relatively low in this nutrient. Although these plants are known to be poisonous to some ruminants, deer consume both of them during the winter months.

Crude fat was higher in the browse material from both management areas than in most forage crops. The crude fiber content of the browse from both areas, tables 2 and 3, was lower than that of most forage crops, and only coconut bush, *Pyrularia pubera,* in stage II, contained more than the 29.0 per cent level listed by Morrison (1945) as the average for "all analyses" of alfalfa hay. The nitrogen-free extract in the browse from both areas was unusually high. It never fell below Morrison's (1945) value of 36.4 per cent for alfalfa hay and occasionally reached twice that value.

With the possible exception of cobalt, the mineral constituents of the browse from Standing Indian Management Area were adequate to meet the requirements of sheep; however, phosphorus was lower than the requirement for deer, according to data reported by French, *et al.* (1955). The high calcium content of all the browse from Standing Indian is remarkable and that for dogwood in particular is astounding. The dogwood browse contained an average of 2.58 per cent calcium compared to a value of 2.25 per cent found in alfalfa leaves (Morrison, 1945). Red maple, with a mean of 0.757 per cent of calcium, was the lowest of any of the Standing Indian Area species analyzed.

The crude protein content of the browse at Holly Shelter was low in all seasons except spring when the plants were in a rapid state of growth. The protein dropped markedly by August and continued to decline through fall and winter. Analyses of the stomach contents of killed deer indicate that *Cyrilla racemiflora* compose about 61 per cent of the diet (Frank Richardson, unpublished data). The crude protein content of *Cyrilla* is less than 9 per cent for nine months of the year. If it is assumed that this is an average level and that a deer consumes 2.2 pounds, dry basis (Nichol, 1938), or about 8.8 pounds fresh forage per day, the crude protein intake will be 90 grams. If the crude protein is 50 per cent digestible, and digestion trials by Forbes, *et al.* (1941) with willow (*Salix humilis*) and panicled dogwood (*Cornus paniculata*) browse and Hagen (1953) with buckbrush (*Ceanothus cuneatus*) indicate this to be liberal, then only 45 grams would be utilized by the animal. This intake is far less than the recommendation of 99 grams of digestible protein for lambs and ewes and 121 grams for lactating ewes (Pearson, *et al.,* 1949). This inadequacy is even more marked when compared with the requirements for optimum growth of deer (French, *et al.,* 1955).

Biswell, *et al.* (1943) reported that, from October through March, native forage plants of cutover forest land in the coastal plain of Georgia contained less than 9 per cent crude protein and barely contained this amount for the remainder of the year, except April. From December through February the crude protein of the diet was lower than the 7 per cent level needed for maintenance of dry cows. A similar study in the Hofmann Forest, which is located near the Holly Shelter Wildlife Management Area in the Coastal Plain of North Carolina, showed a deficiency of total digestible nutrients, especially protein, from January through March. In this area Foster, *et al.* (1945) observed that cows, supplemented during winter and early spring with 2 pounds per day of 36 per cent cottonseed meal, calved normally but lost considerably more weight and weaned slightly fewer and lighter calves than cows fed 4 pounds per day.

Einarsen (1946) reported that deer killed in a recently logged and burned area of northwestern Oregon were outstanding for their large size. It was postulated that the burning of the slash released minerals from the organic matter, and these stimulated the herbage to luxuriant growth to fur-

nish an abundance of food of a high nutritive quality. A study of the browse herbage in the area showed an unusually high protein content, which declined to its lowest value during the winter. Furthermore, there was a gradual decline in the crude protein of the herbage over a period of several years following burning. In the central area of Oregon, deer at about the same stage of maturity and feeding on the same type of browse were only about half the size of the aforementioned large deer. Einarsen (*ibid.*) stated that to supply their need for protein in the latter area, deer must feed 10 to 12 hours per day in summer to maintain health and twice this amount of time in January. He further stated that when the crude protein drops below 5 per cent, a nutritional crisis occurs in the deer herd resulting in heavy losses from starvation.

Longhurst, *et al.* (1952) reported that the number of mule deer that can survive on the Jawbone winter range of California is limited by the amount of high-protein browse available. Their study indicated that the critical protein level is 7 to 8 per cent. When it falls below 7 per cent, up to 40 per cent of the herd may be lost from starvation. Reproductive performance also was seriously affected by inadequate protein intake. For 9 months of the year the browse herbage at Holly Shelter is near the crude protein level that these investigators consider to be critical.

Hagen (1953) reported that when deer die of malnutrition, they do so with their stomachs filled with material that failed to supply the nutrients required to sustain them. Apparently this is of frequent occurrence (Davenport, 1939; Maynard, *et al.*, 1935).

The phosphorus content of the herbage at Holly Shelter followed the same trend as the crude protein, the highest level occurring during the spring when the plants were in a very active state of growth. It was exceptionally high in *Smilax* at this period; however, by August the level of phosphorus in all species dropped to about one-fourth to one-third of that found in the spring and continued at a low and rather constant level for the remainder of the year. It should be noted that the phosphorus content did not drop to so low a level in the Standing Indian Area.

The herbage in the Holly Shelter Area had a phosphorus content of approximately 0.05 per cent for about 9 months of the year, compared to 0.13 per cent at Standing Indian for the same period. Mitchell and McClure (1937) consider a level of 0.12 per cent to be marginal in the diets for sheep, and the National Research Council Committee on Animal Nutrition recommends 0.20 per cent for ewes and lambs (Pearson, *et al.*, 1949). The latter value, however, is lower than the 0.25 per cent that French, *et al.* (1955) found to be inadequate for optimum growth of young deer. The extremely low phosphorus content of the herbage composing the diet probably affects the growth, health, and reproductive performance of the deer in the Holly Shelter Area.

The utilization of even the small amount of phosphorus in the browse at Holly Shelter may be lowered because of the wide calcium-to-phosphorus ratio, which was 13:1 or greater for nine months of the year. The ideal ratio for livestock is considered to be 1:1 to 2:1 (Morrison, 1945). Furthermore, the low phosphorus content of the browse may depress the digestibility of the already low protein as was reported by Morris and Ray (1939) for sheep on a low phosphorus diet.

The calcium level of each browse species collected at Holly Shelter was adequate to meet the requirements of sheep and presumably those of deer at all seasons. It was lowest in *Cyrilla racemiflora*, the most heavily browsed of all species studied in stage II. The calcium content of the browse species at Standing Indian was greater than that at Holly Shelter, which had an average for all species in stage II ranging from 1.6 times greater in winter to 2.5 times greater in the spring.

The cobalt content of the browse was rather constant throughout the year at Holly Shelter. The level of 0.05 p.p.m. is considered to be in the deficient range as a yearly average of 0.07 p.p.m. is about the minimum level at which ruminants remain healthy (Beeson, 1950). Some pastures maintain healthy animals at cobalt levels below 0.07 p.p.m.; however, in this general area of the state (Beeson, 1950), animals grazing some pastures ranging from 0.02 to 0.07 p.p.m. manifested deficiencies. Some of the browse at Standing Indian contained a low level of cobalt, 0.04 to 0.05 p.p.m., which is in the range of that found at Holly Shelter. It

may be that the deer at Standing Indian meet their requirements by having access to other plants such as dogwood, which contains larger amounts of cobalt. An intake of cobalt greater than that found in the browse at Holly Shelter may improve markedly the utilization of other nutrients in the browse herbage through a stimulation of the microorganisms in the rumen.

There were seasonal variations of the other micronutrients at both management areas. The amounts of these elements found in the browse, however, probably are adequate to meet the requirements of domestic livestock and presumably of deer. Manganese and copper were somewhat higher at Standing Indian than at Holly Shelter, while the iron was approximately the same at both locations.

Dasmann (1951) suggests that deer ranges may be improved by thinning with chemical sprays, planting other species, or reducing the herbage to the sprout stage through controlled burning. Fertilization, based on soil analysis of certain subareas in the management area, may improve the nutritive quality of the browse. It may be more economical, however, to supplement the food of deer at feeding stations with a protein-rich material such as cottonseed meal, which also furnishes an appreciable amount of phosphorus. A mineral mixture containing phosphorus and cobalt also could be supplied at feeding stations to provide these elements as needed. A mixture composed of dicalcium phosphate (steamed bone meal or a good grade of defluorinated phosphate rock may be substituted for dicalcium phosphate), 80 parts; sodium chloride (salt), 20 parts; copper sulfate (bluestone), 0.1 parts; and cobalt carbonate, 0.05 parts, should be satisfactory. When the deficiencies of the diet are met, greater utilization of the other nutrients in the browse probably will occur.

## SUMMARY

The browse growing in two wildlife-management areas of North Carolina was analyzed for the calcium, phosphorus, manganese, iron, copper, and cobalt content, as well as for the usual constituents determined by the proximate analysis of feeds. One of these areas, which supported few and unthrifty deer, was the Holly Shelter Area located in the coastal plain. The other, supporting deer of normal size and herd composition, was the Standing Indian Wildlife Management Area in the Pisgah National Forest located in the mountains of western North Carolina.

On the average the browse herbage at Holly Shelter was deficient in protein, phosphorus, and cobalt. Crude fat and nitrogen-free extract were high and the crude fiber was rather low. The nitrogen-free extract was high and relatively constant for all periods. Crude protein and phosphorus were at the highest level in the spring; both decreased markedly by summer, then the former gradually declined to a low in winter while the latter remained rather constant. Calcium was lowest in spring and highest in fall and winter but probably was adequate at all seasons. Manganese, iron, and copper were variable with seasons but probably were adequate at all times for the needs of deer. On the other hand, cobalt was low and relatively constant for all sampling periods. Inadequate protein, phosphorus, and cobalt are the most logical explanations of the poor performance of deer in the Holly Shelter Area. The herbage from the Standing Indian Management Area varied in composition in a manner similar to that from Holly Shelter but appears to be adequate for the requirements of deer, with the possible exception of phosphorus and cobalt. The size of the deer indicates that the requirements for both of these elements probably are met by preferential consumption of such plants as dogwood, red maple, and sweet birch. The calcium content of the herbage at Standing Indian was extremely high.

Suggestions for improving the diets of deer in the Holly Shelter Wildlife Management Area are offered.

## BIBLIOGRAPHY

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1945. Official and tentative methods of analysis. Ed. 6. Washington, D.C.

BARKALOW, F. S. 1942. Deer hunting at Holly Shelter. N.C. Wildl. Conservation, 6(10). 3 pp.

BEESON, K. C. 1950. Cobalt occurrence in soils and forages in relation to nutritional disorder in ruminants. A review of literature. Agricultural Information Bull., 7, U.S.D.A. Agric. Res. Adm., Washington, D.C.

BISWELL, H. H., W. O. SHEPHERD, B. L. SOUTHWELL, AND T. S. BOGGESS, JR. 1943. Native forage plants of cutover forest land in the Coastal Plain of Georgia. Ga. Coastal Plain Exp. Sta. Bull., No. 37. 43 pp. Illus.

——, R. W. COLLINS, J. E. FOSTER AND T. S. BOGGESS, JR. 1945. Native forage plants: Species utilized by beef cattle on forest range in the North Carolina coastal plain. N.C. Exp. Sta. Bull., No. 353. 27 pp. Illus.

COX, B. F. 1950. More about deer disease. Wildlife in N.C., 14(7):19-20. Illus.

DASMANN, WILLIAM P. 1951. Some deer range survey methods. Calif. Fish and Game, 37: 43-52.

DAVENPORT, LA VERNE. 1939. Results of deer feeding experiments at Cusino, Michigan. Trans. N. Amer. Wildl. Conf., 4:268-274.

EINARSEN, ARTHUR S. 1946. Crude protein determination of deer food as an applied management technique. Trans. N. Amer. Wildl. Conf., 11:309-312.

FORBES, E. B., L. F. MARCY, A. LEROY VORIS, AND C. E. FRENCH. 1941. The digestive capacities of the white-tailed deer. J. Wildl. Mgmt., 5: 108-114.

FOSTER, J. E., H. H. BISWELL, AND E. H. HOSTETLER. 1945. Comparison of different amounts of protein supplement for wintering beef cows on forest range in the southeastern Coastal Plain. J. Anim. Sci., 4:387-394.

FRENCH, C. E., L. C. MCEWEN, N. D. MAGRUDER, R. H. INGRAM, AND R. W. SWIFT. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Penn. State Univ., Agric. Exp. Sta. Bull. 600. 50 pp. Illus.

GORDON, AARON, AND ARTHUR W. SAMPSON. 1939. Composition of common foothill plants as a factor in range management. Univ. Calif. Exp. Sta. Bull. 627.

HAGEN, HERBERT L. 1953. Nutritive value for deer of some forage plants in the Sierra Nevada. Calif. Fish and Game, 39:163-175.

HALVERSON, J. O., AND SCHULZ, J. A. 1920. McCrudden gravimetric calcium method modified. Ind. Eng. Chem., 12:77-78.

HELLMERS, HENRY. 1940. A study of monthly variations in the nutritive value of several natural deer foods. J. Wildl. Mgmt., 4:315-325.

KOENIG, R. A., AND C. R. JOHNSON. 1942. Colorimetric determination of phosphorus. Ind. Eng. Chem., Anal. Ed., 14:155-156.

LONGHURST, WILLIAM M., A. STARKER LEOPOLD, AND RAYMOND F. DASMANN. 1952. A survey of California deer herds, their ranges and management problems. Calif. Dept. Fish and Game, Game Bull., 6. 136 pp. Illus.

MAYNARD, L. A. 1951. Animal Nutrition. 3rd ed. McGraw-Hill Book Co., Inc., New York.

——, GARDINER BUMP, ROBERT DARROW, AND J. C. WOODWARD. 1935. Food preferences and requirements of the white-tailed deer in New York State. N.Y. Cons. Dept. and N.Y. State Col. of Agric., Bull. 1. 35 pp.

MITCHELL, H. H., AND F. Y. MCCLURE. 1937. Mineral nutrients of farm animals. Natl. Res. Council Bull., 99. 135 pp.

MORRIS, S., AND C. S. RAY. 1939. The effect of a phosphorus deficiency on the protein and mineral metabolism of sheep. Biochem. J., 33: 1209-1216.

MORRISON, F. B. 1945. Feeds and feeding. 20th ed. Morrison Publishing Co., Ithaca, N.Y.

NICHOL, A. A. 1938. Experimental feeding of deer. Univ. Ariz. Tech. Bull., 75. 39 pp.

PARKS, R. Q., S. L. HOOD, C. HURWITZ, AND G. H. ELLIS. 1943. Quantitative chemical microdetermination of twelve elements in plant tissue. Ind. Eng. Chem., Anal. Ed., 15:527-533.

PEARSON, P. B., H. M. BRIGGS, W. G. KAMMLADE, J. I. MILLER, AND R. F. MILLER. 1949. No. 5. Recommended nutrient allowances for sheep. Committee Anim. Nutrition, Nat. Res. Council. 24 pp.

RUFF, FREDERICK J. 1938. The white-tailed deer of the Pisgah National Game Preserve. U.S.D.A. For. Serv., Southern Region.

——. 1950. What is "black tongue" among deer? Wildlife in N.C., 14(6):16-19. Illus.

SWIFT, R. W. 1948. Deer select most nutritious forages. J. Wildl. Mgmt., 12:109-110.

WELLS, B. W. 1946. Vegetation of the Holly Shelter Wildlife Management Area. N.C. Dept. Cons. and Development, Div. Game and Inland Fisheries. State Bull., No. 2. 40 pp. Illus.

Received for publication November 14, 1955.

## NOTES AND NEWS

With this issue, Dr. Louis A. Krumholz has asked to be relieved of his duties as Associate Editor of the *Journal of Wildlife Management*, a position in which he has served the Wildlife Society with so much distinction during the past four years. To Dr. Krumholz and Dr. Oliver H. Hewitt, who ended a six-year editorial association with the Journal last July, it is a pleasure to extend the hearty thanks of the Society for their unsung efforts to maintain a high standard in our principal publication.

—DURWARD L. ALLEN

# WATERING PATTERNS OF SOME DESERT GAME ANIMALS[1]

*James B. Elder*[2]

Arizona Cooperative Wildlife Research Unit, University of Arizona, Tucson, Arizona

In recent years wildlife administrators in the arid southwest have expended much time and money in developing watering places on desert ranges that contain all of the essential habitat requirements for the production of game except for permanent and available water. Some developments are designed primarily for use by quail and other game birds (Glading, 1947). Access to water is restricted to small game by covered ramps and stockproof fences. Other developments are designed for multiple use by game mammals as well as birds (Halloran, 1949).

From June 1951 to January 1953, I carried on a field study of several man-made, multiple-purpose, game-watering places with the following objectives: (1) to determine the species of desert wildlife utilizing man-made tanks, and to determine where possible which of those species are dependent on them to satisfy their water requirements; (2) to determine daily and seasonal utilization patterns by the different species; (3) to study behavior of different species at water; and (4) to evaluate waterhole counts as a census technique. I obtained utilization data on ten species of mammals and 25 species of birds. Because of space limitations, the present report will consider only the following important game species: mule deer (*Odocoileus hemionus*), javelina (*Pecari angulatus*), white-winged dove (*Zenaida asiatica*), mourning dove (*Zenaidura macroura*), and Gambel's quail (*Lophortyx gambelii*).

## Study Area

*Location and topography.* Most of the field work was conducted in Tucson Mountain Park, located about eight miles west of Tucson in Pima County, Arizona. The park occupies 29,307 acres in the center of the 100,000-acre Tucson Mountain Game Management Unit administered by the Arizona Game and Fish Commission. Elevations range from 2,200 feet to 4,677 feet. On mountains and foothills the terrain is rugged, strewn with boulders, and cut with steep-banked washes. Below the foothills, these washes fan out and lose their steep banks. North and west of the mountains the terrain is level. The mineral soils are predominately reddish or light brown in color, and vary in texture from gravel to fine sand and clay. Large quantities of undecomposed parent material are found on the mountains and foothills and in rock outcroppings on the sandy outwash plain.

*Climate.* The climate of the region is characterized by high temperatures, low average annual rainfall, periodic dry seasons, low relative humidities, and high evaporation rates. As the daily and seasonal waterhole-utilization patterns of the various species are explained largely in terms of climate and weather, these factors will be considered briefly.

During the 184-day period from May 1 through October 31, 1952, maximum daily temperatures in excess of 90°F. were recorded 172 times. Fifty-nine of these records were 100°F. or greater. Minimum daily temperatures during this period never fell below 50°F. and were recorded in the fifties only nine times.

Annual precipitation is distributed over two distinct rainy periods alternating with dry periods. The winter rains, normally falling from December to March, are usually gentle, cover a wide area, and are often of several days' duration. The summer rains,

[1] Contribution from the Arizona Cooperative Wildlife Research Unit: University of Arizona, Arizona Game and Fish Commission, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating. I wish to extend thanks to Dr. L. K. Sowls, leader of the Arizona Cooperative Wildlife Research Unit, under whose direction this study was conducted. In addition, I gratefully acknowledge the advice and assistance rendered me by C. R. Hungerford, Dr. W. H. Brown, and E. D. Clark (all Dept. of Zoology, University of Arizona), J. F. Carithers (Supt., Tucson Mountain Park), Dr. P. L. Errington and B. L. Ridley (Dept. of Zoology and Entomology, Iowa State College), and my wife, Bonnie Jo Elder.

[2] Present address: Dept. of Zoology, Kansas State College, Manhattan, Kansas.

which normally fall from July to September, are usually restricted locally and may last only a few minutes. Large quantities of water may fall in a short period of time with heavy and often destructive runoff, and high evaporation rates. While extremely important to plants and animals on the desert, the summer rains are generally less effective than equal quantities of water falling as winter rains. The amount of rainfall was normal during this study but extended over longer-than-usual time intervals (Table 1).

TABLE 1. — WEATHER AND TANK UTILIZATION BY DEER AND JAVELINA, 1952

| Month | Temperatures (°F) Avg. Max. | Avg. Min. | Avg. | Prec. (in.) | Avg. No. Deer Per Night | Avg. No. Javelina Per Night |
|---|---|---|---|---|---|---|
| Jan. | 69.3 | 41.3 | 52.6 | 0.22 | — | — |
| Feb. | 65.1 | 41.9 | 53.5 | 0.06 | 3 | 6 |
| March | 64.5 | 42.1 | 53.3 | 2.07 | 0.6 | 8 |
| April | 79.1 | 52.7 | 65.9 | 1.02 | 1 | 3 |
| May | 92.6 | 64.9 | 79.8 | 0.07 | 13 | 5 |
| June | 99.2 | 69.0 | 84.1 | 0.55 | 41 | 23 |
| July | 99.7 | 74.6 | 86.2 | 2.61* | 58 | 61 |
| Aug. | 97.7 | 73.7 | 85.7 | 1.28 | 4 | 0 |
| Sept. | 97.3 | 72.2 | 84.8 | 0.71 | 12 | 0 |
| Oct. | 93.7 | 65.3 | 79.5 | 0.00 | 17 | 34 |
| Nov. | 70.1 | 45.1 | 57.6 | 2.24 | 16 | 13 |
| Dec. | 62.5 | 38.3 | 50.4 | 0.54 | 1 | 0 |

*After July 23

*Vegetation.* Tucson Mountain Park lies wholly within the Sonoran Desert (Shreve, 1951). The vegetation strongly reflects the influence of the climatic factors listed above, and xerophytic perennial plants of the region are well adapted for survival during the hot, dry periods between rainy seasons.

Cacti dominate the vegetation in association with varying amounts of creosote bush (*Larrea tridentata*), bursage (*Franseria deltoidea*), mesquite (*Prosopis juliflora*), palo verde (*Cercidium microphyllum*), and ironwood (*Olneya tesota*). Saguaro (*Carnegiea gigantea*) is abundant throughout most of the park and in places forms dense stands. Its fruits are a major source of food and water for many desert birds and mammals. Cholla and prickly pear (*Opuntia* sp.) are less striking but even more abundant than saguaro. The hedgehog cactus (*Echinocereus* sp.), barrel cactus (*Ferocactus wislizeni*), and fishhook cactus (*Mammillaria* sp.) are also common. The fruits of each, in addition to the roots and fleshy pads of prickly pear, are eaten by wildlife.

Jojoba (*Simmondsia chinensis*), important as deer browse, is a common shrub on the rocky foothills and mountainsides. Ratany (*Krameria grayi*) and false mesquite (*Calliandra eriophylla*) are common, and in places they are the dominant undershrubs. Both furnish excellent browse for deer.

*Water areas.* Two of eight game-watering places within the park were studied intensively. These two were constructed by the Arizona Game and Fish Commission in 1947 and are known locally as Deer Trap and Cam-Boh tanks. Water is pumped by windmills from wells and piped to covered concrete reservoirs (measuring 8 by 6 feet by 36 inches), which are continuous with an open tank measuring 6 feet by 6 feet and sloping toward the reservoir to 36 inches. Both tanks are in clearings 30 to 60 feet from concealing cover. At Deer Trap a clump of cholla and ocotillo (*Fouquieria splendens*) 3 feet from the end of the tank affords some protection and concealment for birds and small mammals.

## METHODS OF STUDY

*Direct observation.* Direct observations of the animals at water from blinds and from an automobile parked near the tank furnished the majority of data on species, numbers, time, and behavior. In 1952, I made a minimum of three to five all-night counts plus three to five all-day counts monthly from May through October. These were interspersed with random diurnal and nocturnal counts of from one to six hours in addition to frequent track counts. From January through April and in November and December one or two all-day and all-night counts plus four or five shorter periods of observation monthly, in addition to track counts, permitted me to determine seasonal changes in utilization patterns. I found that a distance of 150 to 200 feet from the tank was optimum when watching from an automobile during daylight hours and on moonlight nights. With binoculars it was possible to identify and count every bird and mammal using the tank from this distance. The animals using the tanks were seldom disturbed by the presence of humans in an automobile. Observers could smoke, open the doors for ventilation,

and even converse quietly as long as they remained within the vehicle. Several times I attempted to watch the tanks from exposed positions away from the automobile, but each time animals would not approach. Both tanks studied are situated within 300 yards of a heavily traveled road which was crossed by many birds and mammals when approaching or leaving the tanks. It was apparent that the animals were accustomed to vehicles.

For use on cloudy or moonless nights where accurate visibility was limited to less than 50 feet, I constructed a portable blind of lumber and heavy burlap. The portable blind could be shifted downwind from the tank.

*Track counts.* During periods of light usage of the waterholes, I was able to obtain daily estimates of deer and javelina utilization by means of track counts. I cleared a circular lane 3 feet wide around Deer Trap tank at a radius of 75 yards, which I checked and smoothed daily. Tracks of five to ten deer plus five to ten javelina were the maximum that usually could be accurately counted. When tracks became too numerous, only an estimate of numbers could be made. It was also possible to distinguish the tracks of fox, bobcat, badger, other small mammals, and quail.

*Weather data.* Temperature and precipitation data for 1952 were secured from a volunteer U.S. Weather Bureau station on the area. Because of the variable nature of rainfall, I placed three additional rain gauges on the area. The precipitation records summarized in Table 1 are averages of the four gauges.

## RESULTS AND DISCUSSION

*Desert mule deer.* The pattern of daily use of man-made tanks by mule deer varied with season; but in general, heaviest daily use was from shortly after sunset until midnight (Fig. 1). From about midnight until an hour before dawn, only a few deer visited the tanks. Use increased during the last hour of darkness but decreased shortly after dawn. During the hot, dry period preceding the summer rains, deer arrived at the tanks earlier (5:00-6:00 P.M.) and watered long after sunrise (8:00-8:30 A.M.). I occasionally saw deer watering during daylight hours in all seasons, but their use of the tanks in daytime was infrequent and unpredictable. The phases of the moon had no discernible effect on this daily pattern.

Both bucks and does frequently approached the tank and drank alone. More commonly, deer drank in groups. Some of these groups were made up entirely of bucks, some of does, while other groups contained both sexes. In the spring and early summer I noted that groups were usually made up of individuals of one sex. Does approached in larger groups (two to fifteen) than did bucks (two to five). There was no indication that the groups of deer seen watering had any particular social organization or behaved as an entity. In all observed instances, behavior at water was interpreted in terms of the individual.

In general the behavior of deer at water was characterized by caution and hesitation. The following description of the behavior of an adult male illustrates the "typical" behavior of a deer at water during the summer dry period. The deer approached boldly along a game trail about 9:00 P.M., until it was about 150 yards from the tank. There it paused, tested the air and appeared to be listening intently. It continued to approach, but more slowly, pausing frequently to examine its surroundings. Nearer the tank it changed its line of approach and circled the tank before finally moving in. The deer was cautious when leaving protective cover and making the final 30 or 40 feet of the approach. The deer appeared nervous and suspicious when it moved in to drink, moving forward slowly with a stiff-legged walk, jumping at slight sounds, and retreating to cover three times before reaching the tank. The deer paused several times while drinking to raise its head and look around, and when finished it left the area hurriedly, again on a game trail but in a different direction.

Of approximately 30 per cent of the total individual observations that differed from the above "typical" behavior pattern, about half, or 15 per cent, can be characterized as hypersensitive, and half as bold. Most hypersensitive deer refused to drink while I was present anywhere in the water area. Others eventually drank after circling the tank several times and making several false starts toward water. When light was suf-

ficient so that individual characteristics could be recognized, such as scars or antler deformities, it was possible to record the number of approaches made by individual deer. The maximum observed was nine by an adult male. On three of the nine approaches, it had reached the tank and begun drinking before being frightened away.

These sensitive deer were frightened by a variety of sounds and movements: a sudden gust of wind rustling the branches of shrubs and trees, a bird or bat swooping across the water, a cough or scraping from the blind or automobile, and even the normal movements of other deer. If one member of a group became startled and bounded off, the others frequently followed, although individuals were generally less sensitive when part of a large group than when they were alone or in a group of two or three. Often, when one member of a group made the final cautious approach and began drinking, others moved in without hesitation and joined the individual at the tank. In most instances the first deer to leave cover and make the approach was a doe.

For those deer the behavior of which I have classified as bold, the visit to water appeared to be a routine activity which did not call for unusual caution. The characteristic circling of the tank, and tense, hesitant approach were absent. Disturbances that frightened other deer merely seemed to arouse their curiosity. These bold individuals did not hesitate to approach and drink while I was stationed in the blind less than 20 feet from the tank. When I attempted to trap doves at Deer Trap tank during June 1952, deer coming to water just before sunset frightened the birds and interfered with the operations. It was actually necessary to chase occasional individuals to make them leave the vicinity. When they persisted in returning to the tank and even pushed the dove trap aside in order to drink, late-afternoon trapping operations were suspended. The behavior of these bold deer was probably responsible for the erroneous opinion of many local residents that the Tucson Mountain mule deer were only semiwild.

A herd of javelina at the tanks did not appear to frighten deer, although they immediately moved out of range of the javelina, and waited in the vicinity of the tank for the herd to leave. The reaction of deer toward bobcats (*Lynx rufus*) was the same as toward javelina. Deer appeared to ignore the presence of the gray fox (*Urocyon cinereoargenteus*).

While moving in the vicinity of the tanks, many deer paused briefly to feed. Palatable shrubs within a 200-yard radius of the tanks were severely hedged, and many were dead.

Two factors preclude the use of nocturnal waterhole counts as a reliable census technique for mule deer in this region during the period of heaviest use prior to the summer rains. One is the lack of data on how many times daily individual deer visit the tanks. From limited observations on naturally marked deer, it was found that some deer watered four times in a single night. It is probable that a detailed marking study would furnish this basic information.

A far more important factor, determined from the behavior studies, is the readiness of many deer to flee at varied and unpredictable disturbances, only to return to the tank a few minutes later and often from a different direction. Since there may be as many as 15 or 20 deer moving about in the shadows near the tank, it is doubtful that even an experienced observer could keep track of these sensitive individuals and thus eliminate repeat approaches. I believe that, at best, waterhole counts of deer in this region can provide only a rough index of relative abundance from year to year or between two or more range units.

Seasonal trends in waterhole use are illustrated in Table 1. The figures represent averages of several daily track counts and/or direct counts during each of the monthly periods. Because of the difficulty in obtaining accurate counts, the figures should be considered as indices. Use of the tanks by deer was minimal during February, March, and April. In May and June there was a steady increase in use, reaching the yearly peak in mid-July prior to the summer rains. Use dropped to almost zero in August, increased in September and October, and then dropped again in November and December.

During the relatively cool and wet months from November to April, succulent forbs were abundant on the study area. Free water was available in rain pools on the desert for varying lengths of time after each rainfall, and the presence of tracks indicated that deer used them. In the intervals be-

tween rains, when the pools were dry, the only source of water available to the deer, other than the tanks, was succulent vegetation. The deer that were not watering at the man-made tanks were presumably deriving sufficient moisture from their food.

From May through mid-July, daily temperatures continued to rise. Most of the precipitation that fell during this period was lost through runoff and evaporation. The high temperatures presumably increased the deer's need for water while, at the same time, the supply of succulent vegetation diminished until by late May all of it except cacti had disappeared. Rain pools and seeps were dry. In order to meet their daily water needs, deer used the man-made tanks. Measurements of water consumption by individuals and small groups of deer during this period showed that the minimum average amount taken by each of 29 deer was 6.3 quarts (Elder, 1954).

As soon as the first substantial summer showers fell late in July, use of the tanks by deer stopped. It was several days before these showers resulted in the appearance of succulent vegetation. During this time temperatures remained high, so that presumably the deer's need for water also remained high. The only source of water prior to the appearance of succulent plants was in rain pools, and these, according to track records, were heavily used by deer. With the appearance of succulent summer annuals an interesting relationship was noted. As long as rain pools contained water, almost no deer visited the tanks. When these sources were dry between showers, daily use of the tanks increased, although at no time did daily utilization approach the May to mid-July figures. It appeared that the succulence did not completely meet the water needs of the deer. Visits to free-water sources were still necessary but less frequent than before the rains.

Biweekly moisture analyses of several staple browse plants (false mesquite, white ratany, jojoba, desert hackberry [*Celtis pallida*], and desert mistletoe [*Phoradendron californicum*]) indicated that variations in the water content of these plants was of minor importance in explaining the seasonal use of waterholes by deer. The water content of individual species seldom varied more than ten to 15 per cent from one analysis to the next, and the average of all species did not vary more than 15 per cent throughout 1952 (Elder, 1953). Annuals and the fruits of cacti, which contained more than 80 per cent water by weight when in season, were probably more important than perennial browse plants in the water relationships of deer and other animals.

In discussing water requirements of mule deer in general, Leopold (1933) concluded that while drinking water was optimum, succulents provided the minimum moisture required by individual deer. Mule deer on desert ranges, as many observers have pointed out, survive hot, dry summers in the absence of open water. The game manager, however, is concerned not only with survival but also with maintaining healthy and productive herds. In my opinion, a moisture intake of succulents during critical dry seasons, even if available, is not meeting a minimum requirement but a marginal one. On the well-watered Tucson Mountain range the deer were able to utilize a wide variety of available browse. Nevertheless, deer apparently lost weight during the critical summer months, and many appeared to be in poor physical condition by August. Although data are lacking, it is probable that mule deer on dry desert ranges fare much worse. Late summer is the normal fawning period in this region. In normal years the fawn drop coincides with the summer rainy season. During years when summer rains are deficient or lacking entirely, it is probable that does have difficulty in meeting their own and their fawn's nutritional requirements.

I conclude, therefore, from a practical management standpoint that optimum and minimum water requirements for desert mule deer in the Tucson Mountain area, and presumably similar desert ranges, are as follows: from early November to about mid-April, drinking water is at an optimum but succulents provide the minimum moisture required; from mid-April through early November drinking water is minimum.

*Javelina.* The javelina or collared peccary was common on the study area. It usually was encountered in herds of from three or four to 30 or 40, averaging about 15. Occasionally, individuals approached the tank to drink, but usually this species came to water in herds.

Although I most frequently saw javelina

watering at night (Fig. 1), their arrival time could not be predicted. During dry seasons, herds usually began arriving at the tanks about one or two hours after dark, but this pattern was not consistent. During periods of heavy usage, as many as six herds visited Deer Trap in a single night. It was probable that part of the total were repeats.

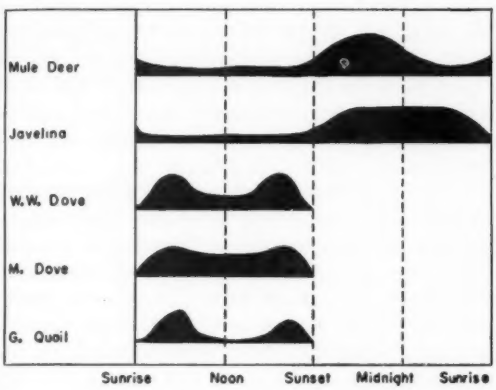



FIG. 1. Periods and peaks of daily waterhole use, Tucson Mountain Park, June-July 1952

The behavior of most herds at water during dry periods was similar to the following description of 17 animals consisting of six juveniles and 11 adults.

I heard them approaching several minutes before they appeared at the tank, their grunting and clicking of hooves on the trail carrying for a great distance. The herd approached along game trails in a single file without pausing. As the file reached the clearing around the tank, it broke up. Seven individuals headed for the tank. Five went first to the salt. The rest milled around the area, rooting and feeding, or seemingly just "keeping watch." When the individuals finished drinking, they left the tank and either went to the salt block or joined in the feeding, as others took their place at the tank. There was no friction between the individuals that were drinking or taking salt. Drinking and salting seemed to be an orderly activity, whereas the individuals feeding in the environs of the tank were often quarrelsome and fights were frequent although of short duration. The sight and sounds of javelina drinking, gnawing salt, rooting and crunching, and rubbing against trees reminded me of domestic hogs in a barnyard. The herd left the water area slowly, feeding and moving about in a loosely knit group. They had remained in the area about 45 minutes.

The division of activities (feeding, watering, and salting) by the individuals of a herd was characteristic of the herds seen watering in the Tucson Mountain area. Only on one occasion did I ever see an entire herd (11 individuals) all go to water at the same time.

Javelina on the study area appeared to be fond of salt and often went directly to the block before going to water. Frequently I saw individuals gnaw the block and then leave the area without watering. I did not determine whether these individuals watered before my arrival or returned later to drink. During the few periods when tanks dried up due to mechanical breakdown, the herds continued to come to the tanks for salt.

Herds of more than 40 have been seen at Deer Trap tank. These often approached the tank in smaller units of five to ten on several different game trails at once. On reaching the tank, large herds behaved as did smaller herds, part of the group going to water or salt, while others fed and milled around.

These behavior patterns held true only when herds failed to detect my presence. Javelina were seldom startled by sudden noises or movements in the blind or automobile, nor were they alarmed by scent when passing downwind of the automobile. However, when my presence in a blind was detected apparently by scent by individuals passing downwind, an alarm call was given alerting the herd, which immediately left the area. The alarm call or reaction of the javelina must be experienced to be fully appreciated. It consisted of a loud, prolonged snort accompanied by a rapid snapping of the canines. Given unexpectedly and close at hand, it was a frightening noise. The excited animals raised the hair on their backs much like angry dogs. When thus frightened from the tanks, the herds appeared reluctant to quit the vicinity entirely. They moved about some 100 to 150 yards from the tank, giving the alarm reaction frequently.

Response to the alarm reaction by large herds differed from that of small herds. For example, while watching one herd from the blind that I estimated to contain more than 40, I was detected by an adult and the alarm call given, but only part of the herd milling

around the tank broke and ran. A few individuals in the rest of the herd paused to watch the departing group, but most ignored the excitement. As other individuals discovered my presence and gave the alarm, other segments of the herd departed. Eventually, the entire herd drifted away in groups of from five to ten. It is my opinion that large herds are an assemblage of several smaller, autonomous units, possibly family groups. When an adult javelina gave the alarm call, only that individual's own group responded.

The distinctive odor of the musk of javelina was noticeable when a herd visited a tank. If the herd was disturbed, or if several individuals rubbed against trees, the musk smell lingered for two or three hours after the herd departed. Contrary to widespread popular belief, I found no indication during this study that the musk of javelina rendered the tanks unfit or distasteful for other species.

Watering javelina appeared to ignore the presence of all other animals except bobcats. It seems unlikely that a herd should have reason to fear a lone bobcat, yet on two occasions I saw herds frightened from Deer Trap tank by the sudden appearance of an adult bobcat. In each instance a few javelina remained in the area about 50 yards from the tank, and the herds returned within ten minutes after the bobcat left. It should be noted that each of the herds contained nursing young.

As with mule deer, javelina were extremely difficult to count at water, especially large herds. They constantly moved about in the shadows in the vicinity of the tank. Although some individuals drank several times before finally leaving the area, others did not drink at all. The uncertainty involved in obtaining an accurate count makes the waterhole census unreliable.

The seasonal pattern of waterhole use was similar to that of deer (Table 1). Monthly figures for javelina were obtained in the same manner and time as those for deer. Factors determining seasonal variation in waterhole utilization by deer are generally applicable to javelina except that the lack of track or sight records during August and September 1952 indicated that javelina utilized succulents during the summer rainy season to a greater extent than deer. For javelina, open water was probably necessary for meeting minimum moisture requirement during the spring-summer and fall dry periods, while succulents met minimum requirements during rainy seasons.

*White-winged dove.* White-winged doves were abundant on the study area from May until September. Their daily watering pattern showed definite morning and afternoon peaks (Fig. 1). According to Arnold (1943), the morning flight to water is undertaken by males, while females remain on the nests. The afternoon flight is composed of females. Sex composition of the morning and afternoon flights on the study area was not determined.

When white-winged doves were undisturbed, their behavior at water followed a definite pattern, which is illustrated by the following example from Cam-Boh tank just prior to the summer rains. The doves gathered in flocks in favored trees and shrubs around the tank. Definite lines of flight to and from the tanks were not noted. While the flock gathered, there was some movement around the area but none to the tank. Several flew to the vicinity of the salt block to take grit. One dove was seen picking the salt block.

The movement of the flock to water began when two of the group flew to the ground near the tank and walked slowly to the edge. After pausing to look around, they drank. Sight of another dove drinking safely was apparently the stimulus needed to attract the rest of the flock to water. For the next three or four minutes the end of the tank was literally covered with doves. When drinking they dipped their beaks an average of two times. Between dips the birds paused and looked around. As soon as one finished drinking, it immediately flew out of the area.

The rush to water continued until all of the doves present in the area had drunk and left. For a few minutes the vicinity of the waterhole was almost empty of white-winged doves. Then the gathering in the trees began again. The time required for the flocks to gather and drink was about 15 minutes.

Doves were readily frightened and scattered by the sudden appearance in the water area of any large birds, for example, turkey vultures (*Cathartes aura*) or marsh hawks (*Circus cyaneus*). It was apparent that the doves were frightened by the sudden swoop-

ing of the vultures and hawks and not by the raptores themselves, for when a vulture or hawk alighted at or near the tank and remained quiet, the doves returned to the water area. On several occasions I saw doves drinking alongside vultures and hawks that had remained perched on the tank for several minutes. Similarly, I occasionally saw doves drinking with deer and javelina, but only after these mammals had been at the tank for several minutes. If the deer or javelina became frightened and ran from the water area, the doves also scattered.

The presence of humans in the water area was disturbing to doves. They refused to water if I was moving anywhere in the area, and they flushed if I approached within 30 yards. They drank if I remained quiet 50 or more yards from the tank. It was possible to watch from an automobile, however, as close as 25 yards without disturbing the doves.

During the 1952 summer dry period at Cam-Boh tank, I began a trapping and marking study using a large box trap with the open water as bait. Thirty doves were banded and marked with yellow or white model-airplane "dope" for later individual recognition. During subsequent all-day counts I observed six of the marked doves at the tank. On one of the counts, four of the marked doves drank once, another drank four times, and one drank five times. Arnold (1943) calculated that some white-winged doves watered twice daily. While results of the marking study were inconclusive, it is apparent that at least some doves watered more than twice daily.

I believe that white-winged doves can be censused at watering places provided that average daily frequency of visits is first determined by means of intensive marking studies. Unlike deer and javelina, a dove requires only a few seconds to finish drinking once it has begun. The likelihood of a dove being disturbed when drinking only to return a few minutes later to finish is very remote. No such instance was ever observed.

White-winged doves arrived on the study area about mid-April and were abundant on the area, utilizing the tank accordingly, from about May 1 until August 30. Utilization dropped rapidly from August 30 until September 30. During October only occasional individuals were seen watering. A few white-winged doves wintered on the area.

The summer rains did not appreciably influence the utilization patterns of the white-winged doves. On July 14, 1952, I recorded 833 doves drinking at Cam-Boh tank. On August 8, 1952, I counted 500. Water was available in rain pools on the desert on August 8. From the figures it is apparent that most of the white-winged doves continued to drink from the tanks rather than from rain pools. I saw doves drinking from rain pools after showers, but I also saw doves fly over these pools enroute to the tanks. Apparently the flight or flights to the tank becomes an established pattern of daily activity to most individuals. By comparison, Arnold (1943) found that, when water was available in rain pools, almost no white-winged doves utilized a tank that he had under observation, although prior to the rains he frequently observed watering flocks numbering in the thousands.

For the white-winged dove, available free water is probably at all times an essential habitat requirement.

*Mourning dove.* Mourning doves were common on the study area although less abundant than white-winged doves. While there was a slight increase in numbers of watering mourning doves in the early morning and late afternoon, there were no pronounced peaks of utilization in the daily watering pattern (Fig. 1). Mourning doves arrived at the tanks earlier in the morning and were seen watering later in the evening than were white-winged doves.

Behavior of mourning doves was similar to that described for white-winged doves. In fact, they usually accompanied the white-wings to water. Some differences in behavior, which were determined at Cam-Boh tank in July and August 1952 were as follows. Mourning doves appeared to be more cautious and shy at water than were white-winged doves. If scattered, they were slow to return to the water area. Mourning doves usually remained in trees and shrubs or on the ground for a longer period before watering. Many mourning doves, when entering the water area, flew directly to the ground within five yards of the tank rather than to trees or shrubs. The presence of mourning doves drinking did not attract others to water as with white-winged doves. When

drinking, the mourning dove usually took its fill in one dip, although four or five dips were not uncommon. After drinking they frequently remained in the water area, either taking grit near the salt block or loafing in trees and shrubs or on the ground.

Time was not available for an intensive trapping and marking study of this species, so that its daily frequency of individual visits to water was not recorded. If this frequency is determined, then simultaneous counts of all watering places on a given range unit should serve as a reliable census of the population. As with white-winged doves, there is little or no chance of repeats by birds that were frightened off before having finished drinking.

A few flocks wintered on the study area and utilized the tanks during the winter months. The main nesting population began arriving in late March and early April. Utilization of the tanks was highest from about May 1 through August 30. Utilization dropped steadily from early September through late October and was minimal from November through March.

As with white-winged doves, available free water appears to be essential to mourning doves.

*Gambel's quail.* Gambel's quail were not abundant on the study area, but frequently watered at the tanks, particularly in late spring and summer. They usually approached and drank during the first two hours after sunrise (Fig. 1). During midday few quail were seen at the tanks. Utilization increased late in the afternoon, although it was never as high as during the early morning hours.

Juvenile quail accompanied the adults to water in the morning but were seldom seen around the tank in the afternoon.

Most data on the behavior of Gambel's quail were obtained from May through October 1952. As this covers much of the normal nesting period (Gorsuch, 1934), my observations are mainly concerned with mated pairs. The following behavior of an adult pair at Deer Trap tank during June 1952 was characteristic of most quail seen in the water areas.

I heard the quail calling in the vicinity of the water area before I saw them. The call was a clucking sound. The pair walked to the tank, their approach slow and cautious. Twice they flew into trees to look around before reaching the tank, and when at the tank were hesitant about beginning to drink. They jumped on and off the rim of the tank several times before walking down the ramp to water. The female began drinking first, and drank for a longer period of time than did the male.

The pair apparently preferred to drink alone. Both male and female became excited and appeared distressed when another pair approached the tank. A brief fight took place between the males. The second pair then moved a few yards away and waited until the first pair had left the tank. The presence of single quail was not tolerated by the drinking pair, and a lone intruder (a male) was driven off by the mated male. When finished drinking, the pair scratched for grit in the bare ground around the tank for about five minutes and then walked out of the water area.

On the same morning a pair was observed at water accompanied by seven juveniles. The behavior of the adults was essentially the same as the pair without young. The only differences were that the male did not drink until both female and young had finished, and that the adults did not pause after drinking to take grit.

The low population density of Gambel's quail on the study area doubtless was a factor influencing quail behavior at water. It is improbable that the above-described individuality so apparent at Cam-Boh and Deer Trap tanks could be possible where tanks or catchments are subjected to use by several hundred adult quail in a short period.

With the appearance of hawks, vultures, road-runners (*Geococcyx californianus*), deer, javelina, foxes, or humans in the water area, quail became very excited and took to cover. Adults without young flew into trees or shrubs. Young were herded quickly away from the tank. As long as the intruder was in the area, adults kept up an insistent alarm call. Quail never appeared disturbed by my presence in an automobile or blind.

I found nothing in the individual behavior of quail at water to prohibit the use of waterhole counts as a census technique, although additional study on the individual daily use patterns is in order, before further evaluation of censusing can be made.

Between May and October, daily waterhole use was highest during late June and July prior to the summer rainy season. I seldom saw quail at the tanks after the first summer rain when water was available in rain pools or in succulent vegetation. Quail tracks were occasionally seen in the tracking lane at Deer Trap during winter months, indicating that quail sometimes took advantage of the available water. Vorhies (1928) and Gorsuch (1934) state that Gambel's quail in Arizona are able to live and bring off successful hatches on succulents alone. It is important to consider, however, that seasonal rainfall and the resulting availability of succulents may vary greatly in distribution and amount from year to year. Even though free water may rarely be an essential habitat requirement, quail catchments and other watering devices provide inexpensive insurance against years of drought.

*Predation.* I found no evidence of predation at or near the watering places. This was remarkable in view of numerous bobcats, coyotes (*Canis latrans*), foxes, hawks and owls, and an occasional mountain lion (*Felis concolor*) which I saw on the study area.

Possible factors involved in the absence of predation at water are (1) the alertness of the various species when watering, (2) the presence of high populations of rodent buffers on the area, and (3) the tendency of the various species (except quail) to water in flocks or groups.

*Tolerance to humans.* The behavior studies convinced me that most individuals of the species using the tanks became tolerant of humans without losing their inherent wildness. This tolerance can be put to practical use by the game manager, as it enables him to make detailed observations of watering animals during critical seasons of the year for checks on physical condition (disease, nutrition, injuries, etc.). In addition, he can develop watering places for wildlife close to sources of supply at houses, ranches or other man-made structures if, in his opinion, wildlife would benefit from the development. An argument against water development in residential areas adjoining game ranges is the possible loss of game and nongame animals through the activities of domestic cats, dogs, and poachers. Losses of this nature were not apparent in the Tucson Mountain region. I visited many privately owned wildlife water developments in this area. At each I found the owners enthusiastic and even possessive toward their wildlife visitors. They were alert for trespassers and careful to curb their dogs. House cats were encountered only infrequently.

## SUMMARY AND CONCLUSIONS

An intensive study of the utilization of two man-made desert watering places by mule deer, javelina, white-winged and mourning doves, and Gambel's quail was conducted in Tucson Mountain Park in southern Arizona from June 1951 to January 1953. Utilization of the tanks by deer and javelina was highest during the spring-summer dry period, with a second, lesser peak in use occurring in October during the fall dry period. Behavior studies indicated that, even if the daily frequency of visits to water is first determined, the difficulty in obtaining accurate nocturnal counts of watering deer and javelina during periods of high usage precludes the use of waterhole counts as a reliable census technique From a practical management standpoint, it was concluded that open water is necessary to meet the minimum moisture requirement for deer in this region from May through October, but that succulents sufficed from November to May. For javelina, open water is at a minimum during the spring-summer and fall dry periods, while succulents were minimum during rainy seasons. Counts made prior to and during the summer rainy season indicated that most white-winged doves continued to use the tanks even when water was available in rain pools on the desert. Behavior studies indicated that white-winged and mourning doves probably can be censused at watering places during the spring-summer dry period provided the daily frequency of visits to water is first determined. Available free water is apparently essential at all times for white-winged and mourning doves. Gambel's quail used the tanks during the spring-summer dry periods but were seldom seen at water when succulents were available. No evidence of predation was observed at or near the tanks. Although the different species appeared tolerant of the presence of humans near the tanks, there was no indication that they had lost their inherent wildness.

### LITERATURE CITED

ARNOLD, LEE W. 1943. The western white-winged dove in Arizona. Ariz. Game and Fish Comm., Phoenix. 103 pp.

ELDER, JAMES B. 1953. Utilization of man-made waterholes by wildlife in southern Arizona. Unpubl. M.S. thesis, Univ. Ariz. Library, Tucson.

———. 1954. Notes on summer water consumption by desert mule deer. J. Wildl. Mgmt., 18:540-541.

GLADING, BEN. 1947. Game watering devices for the arid southwest. Trans. N. Amer. Wildl. Conf., 12:286-292.

GORSUCH, DAVID M. 1934. Life history of the Gambel quail in Arizona. Biol. Sci. Bull. No. 2, Univ. Ariz. Bull. 5(4). 89 pp.

HALLORAN, ARTHUR F. 1949. Desert bighorn management. Trans. N. Amer. Wildl. Conf., 14: 527-537.

LEOPOLD, ALDO. 1933. Game management. Charles Scribner's Sons, New York. 481 pp.

SHREVE, FORREST. 1951. Vegetation of the Sonoran desert. Carnegie Inst. Washington Publ. 591. 192 pp.

VORHIES, CHARLES T. 1928. Do southwestern quail require water? Amer. Nat., 62:446-452.


Received for publication November 14, 1955.

# CHANGES IN NORWAY RAT POPULATIONS INDUCED BY INTRODUCTION OF RATS

*David E. Davis and John J. Christian*

Division of Vertebrate Ecology, Johns Hopkins School of Hygiene and Public Health, Baltimore 5; Naval Medical Research Institute, Bethesda, Maryland

The introduction of aliens into an existing population of mammals may be followed by unexpected effects that relate to social structure and population composition. These effects were studied by introducing alien rats into stationary and increasing populations of rats in city blocks. This work is part of a continuing study of the mechanisms of change in vertebrate populations using Norway rats (*Rattus norvegicus*) in residential areas in Baltimore as experimental animals (Davis, 1953). These rats inhabit back yards, basements, and garages and feed on garbage. The human sanitary conditions in general are poor and remain unchanged for months at a time, so that the food supply of the rats has only slight seasonal variations. Other environmental conditions are similarly subject to little change for many months at a time. The constancy of these factors permits experiments on populations in a relatively stable environment. Finally, the population of rats in each block is essentially discrete and isolated, as rats rarely travel from one block to another (*see* Davis, 1953, for references).

## METHODS AND PROCEDURES

The procedures followed to study the effects of introducing strange rats into a population consisted of taking some rats from a stationary or increasing population in one block and introducing them into a comparable population in another block and observing the resulting changes in the second population. The status (stationary or increasing) of the population was determined by estimates at bimonthly intervals for more than a year. Blocks that appeared to be either stationary or increasing were selected in October and monthly estimates made. From this group 4 stationary and 4 increasing populations were chosen. To get a base line for adrenal weights, six rats of one sex, weighing over 200 grams each, were removed from each block during the first experimental week (week 1). Alien rats were then introduced into each block during the third week, and at the same time native rats were removed from the increasing populations. The details of these removals and introductions are contained in tables 2 and 3. Estimates were made during the sixth and eighth

weeks, each followed by the removal of a small sample of rats for adrenal weights. The adrenal weights were expressed for each sample as the mean per cent of standard reference values (Christian and Davis, 1955). The rats to be introduced into a population were individually marked by toe-clipping prior to introduction, whereas the native rats were not marked. The details of the history of each population were complicated by the impossibility of introducing exactly the same number of rats into each block on exactly the same days, and the numerical population size also differed in each block.

A discussion of the likelihood of error is desirable when it is claimed that two populations differ in number, since the detection of changes is fundamental to the conclusions derived from these introductions. Some aspects of the census method were discussed by Brown, *et al.* (1955). However, the basic problem is that, even with trapping, the true number of rats in a block is not known. Nevertheless, a check on the validity of estimation can be made by comparing estimates before and after a trapping program. Suppose that an estimate of $N_1$ rats is first obtained, subsequently T rats are removed and a second estimate of $N_2$ rats is made. Obviously $N_1$ should equal $T + N_2$. A figure for percentage of error can be given as $\frac{N_1 - (T + N_2)}{N_1}$. For example, if the estimate for a block is 151 rats and then 81 are removed by trapping and an estimate of 63 is made, then $\frac{151 - (81 + 63)}{151} = 4.6$ per cent. Other procedures could be used such as $\frac{T - (N_1 - N_2)}{T}$ or $\frac{N_1 - T - N_2}{N_1 - T}$. The first procedure is preferred because it bases the calculations on $N_1$, which is the estimate that was used to determine the status of the block. A total of 50 populations was available to determine the extent of error. Each had been trapped during the past 6 years, and an estimate had been made before trapping and another within a month after cessation of trapping. Naturally, some changes can occur during the intervening month, but for practical reasons it is usually not possible to make an estimate promptly after the cessation of trapping. These blocks contained 3,707 rats by the estimates ($N_1$) and 1,502 were trapped. The number of rats per block varied from 15 to 182. The distribution of errors is given in Table 1. The percentage of error was independent of the number of rats in the population. From these differences the standard error of the difference can be calculated to be 10.7 per cent. This value can be used as an indication of the errors to be expected in estimates of population changes in blocks. For example, from Table 2 it is seen that the estimate (block 150128) before introduction was 116 and after was 89. The percentage difference is 23.3 which when divided by 10.7 gives a ratio of 2.2. This difference appears to be statistically significant.

TABLE 1. — DISTRIBUTION OF DIFFERENCES AMONG ESTIMATES

| Per cent Error* | Blocks | | Total |
|---|---|---|---|
| | Positive | Negative | |
| 0–9 | 13 | 6 | 19 |
| 10–19 | 6 | 11 | 17 |
| 20–29 | 4 | 4 | 8 |
| 30–39 | 2 | 3 | 5 |
| 40–49 | 1 | 0 | 1 |
| Totals | 26 | 24 | 50 |

* $\frac{N_1 - (T + N_2)}{N_1}$

## RESULTS AND DISCUSSION

The histories of the populations are given by blocks in tables 2 and 3 and figures 1, 2, and 3. The terms "replacement" and "supplement" require clarification for this discussion. We mean by replacement that approximately the same number of rats was introduced as was removed. Supplement means that many more alien rats were introduced than were removed. A quantitative percentage might have been used to distinguish these two terms, but it would have been rather meaningless because (1) the size of the individual rats varies considerably, and (2) immediate mortality is probably high. Therefore, we really do not know the actual number of rats that produced the results. Another factor is that births and deaths are normally high in any population of rats. The average monthly death rate is about 20 per cent for stationary rat populations; therefore, their birth rate is also about 20 per cent. Comparable mortality and birth rates for increasing populations are prob-

TABLE 2. — RESULTS OF INTRODUCTION OF RATS INTO STATIONARY POPULATIONS

| Block number . . . . . | 140338 | | 140344 | | 140118 | | 150128 | |
|---|---|---|---|---|---|---|---|---|
| Zero week is . . . . . | Dec. 16 | | Dec. 16 | | Feb. 9 | | Feb. 9 | |
| | Week | Rats | W | R | W | R | W | R |
| Population | −20 | 62 | −20 | 30 | −19 | 105 | −18 | 122 |
| Population | −13 | 42 | −13 | 32 | −11 | 98 | −10 | 118 |
| Population | − 5 | 40 | − 5 | 38 | − 6 | 87 | − 6 | 120 |
| Population | 0 | 49 | 0 | 35 | 0 | 100 | 0 | 116 |
| Rats removed | 1 | 6M | 1 | 6F | 1 | 6F | 1 | 6M |
| Rats introduced | 3 | 10M | 3 | 8F | 2-6 | 23F | 2-6 | 27M |
| Rats removed | — | — | — | — | — | — | — | — |
| Population | 6 | 45 | 6 | 44 | 6 | 76 | 7 | 89 |
| Rats removed | 6 | 6M | 6 | 6F | 6 | 6F | 7 | 6M |
| Population | 8 | 56 | 8 | 23 | 11 | 63 | 10 | 86 |
| Rats removed | 8 | 22 | 8 | 12 | 11 | 27 | 10 | 36 |
| | Week | Index[1] | W | I | W | I | W | I |
| | 1 | 83.0 | 1 | 91.8 | 1 | 93.4 | 1 | 79.2 |
| Adrenal size | 6 | 84.1 | 6 | 85.3 | 6 | 90.4 | 7 | 71.4 |
| | 8 | 88.0 | 8 | 102.4 | 11 | 68.4 | 10 | 73.6 |

[1] Mean of the individual per cent of appropriate reference value for the sex and size of the rat.

ably about 15 per cent and 25 per cent per month respectively. It is unwise, under these circumstances, to attempt a precise measurement of numerical differences in the numbers of rats used.

The population estimates (Table 2) in the two replacement blocks 6 weeks after the introduction of rats showed (Fig. 1) that block 140338 was not significantly different from the previous estimate, while block 140344 had apparently increased (P is about .04). While the apparent difference in results in these 2 blocks might be due to sex (the females less disturbing) or to numbers (fewer introduced into 140344), no interpretation will be attempted for the reasons cited above. The two supplemented blocks declined significantly (P is about .04 for each) (Fig. 1).

We recognize that the replacement pair of populations was done in December 1953, and the supplemented pair in February 1954, and that differences might be due to some seasonal aspect. However, the only known seasonal change, an increase in breeding from December to February, would produce the opposite result.

Population growth ceased in all four increasing populations following the replacement of native with alien rats (figs. 2, 3,). In no block was the difference statistically significant. It apparently made no difference whether the sex of the introduced rats

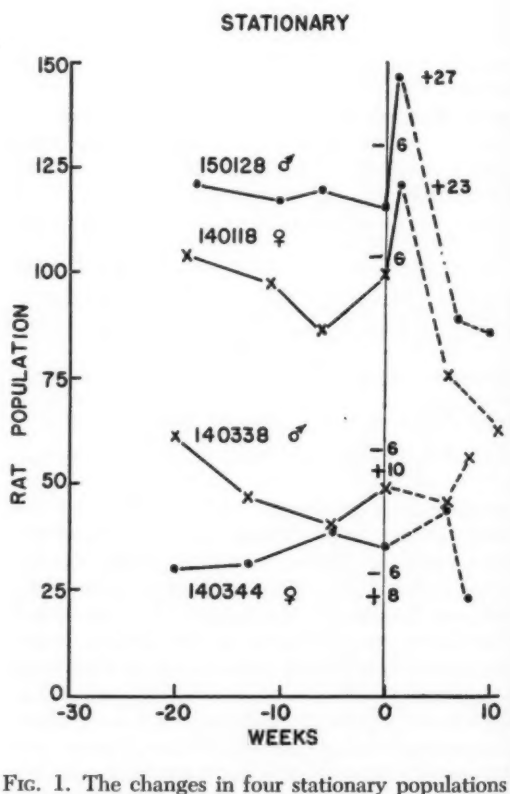



FIG. 1. The changes in four stationary populations for 20 weeks before introduction of rats (at 0 time) and about 10 weeks after. The number added is indicated by a plus sign, the number removed by a minus sign.

TABLE 3. — RESULTS OF INTRODUCTION OF RATS INTO INCREASING POPULATIONS

| Block number . . . . . | 140111 | | 140134 | | 140201 | | 140222 | |
|---|---|---|---|---|---|---|---|---|
| Zero week is . . . . . | Dec. 16 | | Dec. 16 | | Feb. 9 | | Feb. 9 | |
| | Week | Rats | W | R | W | R | W | R |
| Population | −20 | 110 | −20 | 80 | −25 | 86 | −20 | 57 |
| Population | −13 | 118 | −13 | 88 | −16 | 100 | −14 | 62 |
| Population | − 5 | 133 | − 4 | 115 | − 8 | 105 | − 5 | 95 |
| Population | 0 | 150 | 0 | 140 | 0 | 135 | 0 | 90 |
| Rats removed | 1 | 6F | 1 | 6F | 1 | 6M | 1 | 6M |
| Rats introduced | 3 | 22F | 3 | 28F | 3 | 18M | 3 | 20M |
| Rats removed | 3 | 28F | 3 | 22F | 3 | 20M | 3 | 18M |
| Population | 6 | 167 | 6 | 130 | 6 | 130 | 6 | 85 |
| Rats removed | 7 | 6F | 7 | 6F | 7 | 6M | 7 | 6M |
| Population | 10 | 152 | 10 | 130 | 10 | 130 | 10 | 70 |
| Rats removed | 10 | 48 | 10 | 73 | 10 | 57 | 10 | 24 |
| | Week | Index[1] | W | I | W | I | W | I |
| | 1 | 92.1 | 1 | 91.5 | 1 | 104.4 | 1 | 93.8 |
| Adrenal size | 7 | 93.8 | 7 | 102.8 | 7 | 85.3 | 7 | 99.1 |
| | 10 | 101.5 | 10 | 90.4 | 10 | 91.1 | 10 | 84.6 |

[1] Mean of the individual per cent of appropriate reference value for the sex and size of the rat.

was male or female. The population from block 140222 (Fig. 2) may have become stationary just prior to the introduction of aliens, but the high rate of reproduction (4/6 mature females were pregnant) suggests that the population was increasing. The population in block 140111 increased numerically after the introduction, but the difference between the two estimates is within the error of estimate and does not indicate a change in population. It appears that introducing a number of alien rats may halt the growth of increasing populations.

The reader may have noticed that the total number of rats removed from the four increasing blocks was about 5 per cent greater than the number introduced, so that the rats in these populations were not replaced in the strict arithmetic sense of the word. However, considering the previously mentioned birth and mortality factors, it is not desirable to be more precise. All aspects considered, it is likely that the four increasing populations were somewhat reduced following replacement procedures. The four blocks (taken together) increased by 173 rats in the 20 weeks preceding replacement, so that they might have been expected to have had 600 rats 10 weeks after replacement instead of the observed 482, although the rate of increase would decline as the population increased.

On several occasions episodes have been noted that appear to be explainable on the basis of introduction or actual immigration. In January 1946, about 60 rats were released in a block in one night as part of an experi-

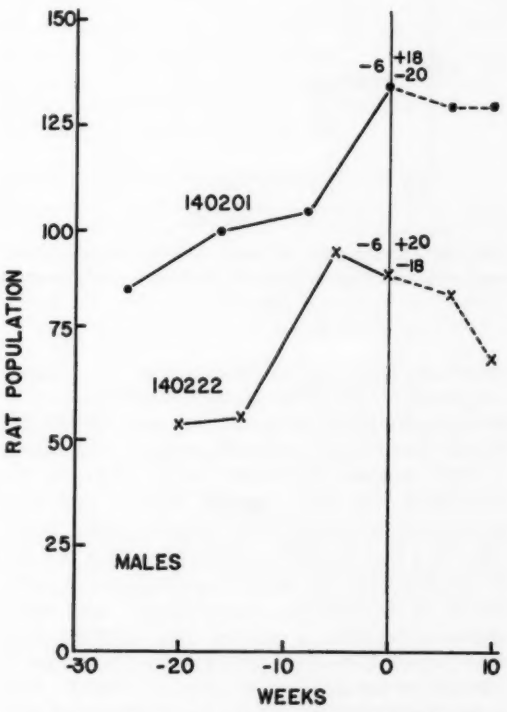



FIG. 2. The changes in two increasing blocks before and after the introduction of males (symbols as in Fig. 1.)

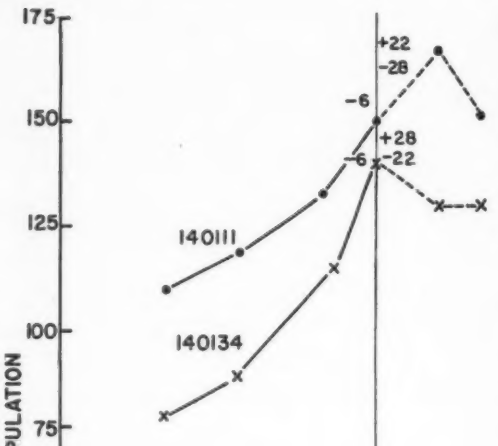



FIG. 3. The changes in two increasing blocks before and after the introduction of females (symbols as in Fig. 1.)

ment on "homing" ability in rats. The block originally contained about 100 rats but within 3 weeks there were so few rats left in the block that the project was stopped. Calhoun (1948) noticed the same result when he introduced rats into blocks. These episodes, as well as miscellaneous observations, stimulated a test in 1947 of the idea that the introduction of rats into a population would result in its decline. Accordingly, rats were introduced over a period of 4 months into two populations that had just reached a level judged to be stationary (Davis, 1949). The introduction of 90 rats in one block and 101 in the other was accompanied by declines of about 25 per cent and of 40 per cent respectively. The populations increased after the introductions ended.

The present experiments suggest that the introduction of large numbers of rats into a population disrupts the population mechanisms in some way that causes the populations either to decline in numbers or stop growing.

The decrease is due in part to a decline in reproduction. Data are not available for the period immediately after introduction, as it is not feasible to follow the population changes and simultaneously to collect a number of rats for reproductive data. However, the large sample of rats collected from the blocks 8 to 11 weeks after introduction had a high reproductive rate (Table 4) and a low lactation rate. One would conclude from these data that the number of pregnancies was low immediately after the introduction. Only about 25 per cent of the females were lactating at 10 weeks, whereas normally about 40 per cent of the females of these rats are lactating (Davis, 1953). The high prevalence of pregnancy presumably resulted from their more or less simultaneous recovery from the effects of introduction. The decreases in rat populations obviously may have been due largely to mortality and movement, but data on this aspect are impossible to obtain under these conditions.

TABLE 4. — REPRODUCTIVE RECORDS OF LOCAL RATS CAPTURED 8-11 WEEKS AFTER ARTIFICIAL IMMIGRATION OF RATS INTO BLOCKS

| Population status | Number Mature Females | Per cent Pregnant | Mean Number Embryos | Per cent Lactating |
|---|---|---|---|---|
| Increasing | 85 | 33.0 | 10.38 | 20.0 |
| Stationary | 66 | 31.8 | 9.63 | 28.8 |

Previous experiments have shown that the weight of the adrenal glands in rats responds to changes in population. An increase in adrenal weight parallels increases in population; the artificial reduction of a population also results in a decrease in adrenal weight (Christian, 1954; Christian and Davis, 1955). The adrenal responses of the two sexes are parallel (*ibid.*). Experiments have indicated that changes in adrenal weight in response to changes in population result primarily from changes in cortical mass (Christian, 1955a, 1955b, 1956). To examine these problems, the adrenals of the rats from each block were removed and weighed. The observed adrenal weight for each rat was compared with a standard reference weight for the appropriate sex and size (length of head and body) of rat (Christian and Davis,

1955), and expressed as a per cent of the reference value. These percentages for the rats from each sample were averaged and the means are recorded at the bottom of tables 2 and 3. We have used the mean value of a given sample as the unit of measurement for comparing adrenal weight with population size (Christian, 1954; Christian and Davis, 1955).

The results indicate that, in the replacement stationary blocks (140338 and 140344), there was a small increase in adrenal weight after 8 weeks, while the populations apparently remained practically unchanged (tables 2 and 3, Fig. 1).

A mean decline in population size, paralleled by a decrease in adrenal weight in at least one of the two blocks, followed the addition of a large number of alien rats to stationary populations (blocks 140118 and 150128). The adrenal weights probably reflect largely the final results of population manipulation rather than the immediate effects, as the adrenal samples were obtained several weeks after the introductions or estimates. Therefore, the changes in adrenal weight probably reflect overall population changes rather than any immediate social strife resulting from the introductions. An experiment to collect samples a few days after the introductions is in progress and may show an increase in adrenal weight.

The adrenal glands of rats from the increasing blocks showed no consistent change, although population growth terminated (Table 3, figures 2 and 3). The replacement of rats in increasing populations had little effect on the adrenal weights of rats examined 10 weeks later.

The results reported here may be applicable to certain stocking programs. A routine part of many game-management programs has been the introduction of a number of animals into an area with the expressed hope of increasing the population either directly or eventually by reproduction. Indeed, such stocking has often been considered a panacea for all hunting problems. The present results, using rats as experimental animals, show that the disruption of a population following an introduction may actually produce a decline under certain conditions. Evidently the introduction of a number of animals may have disastrous results when a population is above the halfway point on a growth curve.


## SUMMARY

Wild Norway rats (*Rattus norvegicus*) were introduced from one city block to another to simulate immigration. The population changes were determined by frequent estimates for about 20 weeks before introduction and 8 to 11 weeks thereafter. From two blocks with stationary rat populations, some rats were removed and then replaced by aliens. The populations remained stationary. In two blocks about four times as many rats were introduced as were removed. The populations declined about 25 per cent. In four blocks with increasing populations about one-fourth of each population was removed and replaced by alien rats from other blocks. The increase halted.

The reproductive rate 8 to 11 weeks after the introduction was normal for an increasing population, but the lactation rate was low, indicating that the decline in population growth was due in part to a decreased reproductive rate, and that the population was back to normal pregnancy rate in two months. The adrenal weights were also essentially normal for the population level two months after introduction.


## REFERENCES


BROWN, R. Z., W. SALLOW, DAVID E. DAVIS, AND W. G. COCHRAN. 1955. The rat population of Baltimore 1952. Amer. J. Hyg., 61(1):89-102.

CALHOUN, J. B. 1948. Mortality and movement of brown rats (*Rattus norvegicus*) in artificially super-saturated populations. J. Wildl. Mgmt., 12(2):167-172.

CHRISTIAN, J. J. 1954. The relation of adrenal size to population numbers of house mice. Sc. D. dissertation, Johns Hopkins Univ., Baltimore.

——. 1955a. Effect of population size on the adrenal glands and reproduction organs of male mice in populations of fixed size. Amer. J. Physiol., 182(2):292-300.

——. 1955b. Effect of population size on the weights of the reproductive organs of white mice. Amer. J. Physiol., 181(3):477-480.

——. 1956. Adrenal and reproductive responses to population size in mice from freely growing populations. Ecology, 37(2):258-273.

—— AND D. E. DAVIS, 1955. Reduction of adrenal weight in rodents by reducing population size. Trans. N. Amer. Wildl. Conf., 20:177-189.

DAVIS, D. E. 1949. The role of intraspecific competition in game management. Trans. N. Amer. Wildl. Conf., 14:225-231.

——. 1953. The characteristics of rat populations. Quart. Rev. Biol., 28(4):373-401.


Received for publication October 24, 1955.

# WATERFOWL SEX RATIOS DURING SPRING IN WASHINGTON STATE AND THEIR INTERPRETATION

*Paul A. Johnsgard and Irven O. Buss*

Department of Zoology, State College of Washington, Pullman, Washington

Sex-ratio studies have received much attention from research workers in recent years. The contributions of Hochbaum (1944), Petrides (1944) and others have yielded considerable information on sex ratios in waterfowl; Beer (1945) and Yocom (1949) have presented data for the state of Washington. To interpret regional data on waterfowl sex ratios adequately, it is necessary to obtain a series of uninterrupted observations covering the entire migration period of the species concerned. In 1954, an ecologic study was conducted in the Potholes area, Grant County, central Washington (Johnsgard, 1956). During the period February 15 to May 16, sex-ratio data were collected for more than 15,000 ducks, including 17 species to be discussed in this paper. Nearly all these species wintered in the region and were present in small numbers when field work began in February (Johnsgard, 1954).

Sex counts were obtained for several types of habitat during this study. Among these were the potholes which occur between the sand dunes that were deposited in the region during glacial times (Bretz, 1928). Following the recent construction of O'Sullivan Dam and the subsequent filling of Potholes Reservoir, many of these potholes were inundated by the rapid rise of the reservoir. However, seepage below the dam has resulted in the formation of numerous lakes and smaller water areas in the scabland channels previously covered with sagebrush (*Artemisia tridentata*) and associated vegetation. Counts on these new seepage areas, as well as counts obtained on Potholes Reservoir, were recorded separately from those obtained on the sand-dune potholes.

## Methods

Sex counts were made directly with the aid of a six-power binocular during daily surveys of the study areas. Only birds definitely identified as to sex were included. There is little likelihood that many birds were overlooked because of the relative scarcity of emergent vegetation in most of the habitats studied. However, it is probable that a certain amount of unavoidable duplication did occur. Ratios have been calculated (males per 100 females, total sample in parenthesis) in all cases where 100 or more individuals were recorded for a given time interval or habitat. In cases where fewer than 100 birds were recorded the total number of males and females is presented, but no ratios were calculated. Choosing 100 individuals as the minimum acceptable sample is wholly arbitrary and is not based on statistical tests.

## Observations

As is usual among waterfowl, diving ducks observed in this study tended to exhibit a more disproportionate sex ratio than surface-feeding ducks. Furthermore, ratios of several diving duck species (redhead, common golden-eye, buffle-head, common merganser) tended to become less disproportionate as the migration period progressed. The ruddy duck exhibited a more disproportionate sex ratio near the end of the migration period.

Sex ratios of any single species varied at any given time as a result of at least two influences. First, sex ratios were more unbalanced on areas subject to human disturbance. Paired birds were the first to flush and the last to return to a disturbed area. Birds preoccupied in courtship display were noticeably less wary than paired birds. This same behavior was manifested by field-feeding mallards. Whenever a flock of these birds was flushed, a definite sequence of events could be observed. The first birds to return to the field were invariably a few single males, apparently searching for mates from which they had been separated during flushing. These birds would circle a few times, calling occasionally, but never landing. Later, numerous small flocks of unpaired birds would arrive, typically a single female and two or more males. These birds were the first to land, and were later followed by large groups of mostly paired birds. Thus the

obtaining of sex counts on disturbed areas during the mating period is likely to be markedly influenced as a result of this phenomenon. Yocom (1949) indicated that sex counts of mallards obtained in winter and early spring on the Snake River near Clarkston, Washington, were usually more disproportionate than those obtained along portions of the river which are less frequented by humans.

Second, sex ratios during any single period varied with the characteristics of the habitat. Most mating activities of the surface-feeding ducks occurred on the shallow seepage areas below O'Sullivan Dam; diving ducks courted on the deeper lakes below the dam, along the edge of the reservoir, or on the deeper sand-dune potholes (Johnsgard, 1956). Following mating, many pairs separated from the main flocks and moved to the smaller *Scirpus-* and *Juncus*-lined sand-dune potholes, where food and cover were more available. Perhaps the greater seclusion and freedom from disturbance by bachelor drakes partially accounted for this behavior. Hochbaum (1944) mentioned that paired canvas-backs usually separate from the unpaired birds and frequent the tule edges. In spring observations on the Snake River near Clarkston, Washington, Stout *et al.* (1955) reported: "Early in the study most of the mallards observed in the eddy were unmated. As the study progressed the mated birds tended to move on down the river. The bachelor drakes remained in the eddy."

As a result of the behavior described above, the sex ratios obtained in the more densely vegetated sand-dune potholes were more nearly equal than those counts obtained on the reservoir and seepage areas below O'Sullivan Dam. These differences in sex ratios are presented in Table 1 to illustrate this point. Data for the period February 15-21 are not included in the table, since the sand-dune potholes were still frozen at that time and all waterfowl were congregated in the seepage areas.

A certain degree of habitat preference is demonstrated in this table, the case of the ring-necked duck and canvas-back being most evident. The canvas-back used the seepage lakes almost exclusively during the courting period; since very few birds paired before departure, they were rarely observed in the sand-dune potholes. On the other hand, the ring-necked ducks moved from the seepage areas into the sand-dune potholes as soon as these were free of ice, where the birds continued courtship display. Common mergansers were never recorded in the potholes, but remained on the deeper lakes where they undoubtedly fed on fish and other aquatic animal life. Although the common goldeneye and buffle-head courted in the potholes as well as the seepage lakes, in the former they inhabited only those potholes that were deep and free of most vegetation.

As indicated in Table 2, there were only

TABLE 1. — LOCATIONAL VARIATIONS IN SEX RATIOS

| Species | February 22 to May 16 | | | |
|---|---|---|---|---|
| | Potholes | | Reservoir and Seepage Areas | |
| Mallard (*Anas platyrhynchos*) | 118:100 | (2,709) | 150:100 | (1,545) |
| Gadwall (*A. strepera*) | 113:100 | (117) | 109:100 | (367) |
| Baldpate (*Mareca americana*) | 112:100 | (138) | 139:100 | (661) |
| Pintail (*Anas acuta*) | 113:100 | (428) | 135:100 | (564) |
| Green-winged Teal (*A. carolinensis*) | 105:100 | (485) | 121:100 | (287) |
| Blue-winged Teal (*A. discors*) | (20:20) | | (1:1) | |
| Cinnamon Teal (*A. cyanoptera*) | (48:50) | | (8:8) | |
| Shoveller (*Spatula clypeata*) | 113:100 | (185) | (64:28) | |
| Redhead (*Aythya americana*) | 128:100 | (476) | 248:100 | (111) |
| Ring-necked Duck (*A. collaris*) | 158:100 | (432) | (6:1) | |
| Canvas-back (*A. valisineria*) | (8:6) | | 418:100 | (294) |
| Lesser Scaup (*A. affinis*) | 177:100 | (411) | 379:100 | (1,423) |
| Common Golden-eye (*Bucephala clangula*) | 97:100 | (382) | 170:100 | (310) |
| Barrow's Golden-eye (*B. islandica*) | — | | (26:14) | |
| Buffle-head (*B. albeola*) | 81:100 | (350) | (51:38) | |
| Ruddy Duck (*Oxyura jamaicensis*) | (30:23) | | 147:100 | (951) |
| Common Merganser (*Mergus merganser*) | — | | 161:100 | (615) |

TABLE 2. — SEASONAL VARIATIONS IN SEX RATIOS

| | Feb. 15-March 28 | | March 29-May 16 | | Total Feb. 15-May 16 | |
|---|---|---|---|---|---|---|
| Mallard | 132:100 | (3,018) | 129:100 | (1,996) | 131:100 | (5,014) |
| Gadwall | 111:100 | (175) | 108:100 | (335) | 109:100 | (510) |
| Baldpate | 135:100 | (443) | 147:100 | (408) | 140:100 | (851) |
| Pintail | 122:100 | (534) | 130:100 | (501) | 126:100 | (1,035) |
| Green-winged Teal | 123:100 | (202) | 112:100 | (667) | 114:100 | (869) |
| Blue-winged Teal | — | | (21:21) | | (21:21) | |
| Cinnamon Teal | — | | 97:100 | (114) | 97:100 | (114) |
| Shoveller | (16:7) | | 135:100 | (254) | 141:100 | (277) |
| Redhead | 198:100 | (175) | 140:100 | (463) | 152:100 | (638) |
| Ring-necked Duck | 171:100 | (152) | 159:100 | (329) | 163:100 | (481) |
| Canvas-back | 416:100 | (558) | (15:7) | | 404:100 | (580) |
| Lesser Scaup | 279:100 | (528) | 317:100 | (1,327) | 305:100 | (1,855) |
| Common Golden-eye | 124:100 | (689) | 87:100 | (170) | 116:100 | (859) |
| Barrow's Golden-eye | (8:3) | | (18:11) | | (26:14) | |
| Buffle-head | 103:100 | (189) | 81:100 | (299) | 89:100 | (488) |
| Ruddy Duck | 99:100 | (173) | 153:100 | (865) | 142:100 | (1,038) |
| Common Merganser | 228:100 | (479) | 51:100 | (136) | 161:100 | (615) |

minor variations in the sex ratios of surface-feeding species between the first and second half of the migration period. Although there are several inherent weaknesses in applying statistical tests to determine the significance of such variations, such tests suggest that the seasonal variations of the redhead, common golden-eye, ruddy duck and common merganser sex ratios are of a significant magnitude.

A differential sex migration would explain some of these variations in those species that pair on the breeding grounds (cf. Nice, 1937; and Tinbergen, 1939), but this explanation has limited application to waterfowl, which are usually paired before their arrival on the breeding grounds. Possible exceptions to this are the ruddy duck and the common merganser, both of which apparently exhibit a true differential sex migration.

An early spring preponderance of males followed by approximately equal numbers of males and females has been noticed in blue-winged teal in Minnesota (Erickson, 1943) and in teal (*Anas crecca*), shoveller, and pintail in the Netherlands (Lebret, 1950). This suggests to us that females may winter somewhat farther south than the males. Females are apparently more sensitive to cold than males (Harrison and McLean, 1947), often beginning their fall migration southward before the drakes (Leopold, 1919).

A differential migration between adult and juvenile birds would help account for a late spring equalization in sex ratios for those cases where immature plumages of males closely resemble those of the female. This later migration of juveniles has been noted in redwings (*Agelaius phoeniceus*) (Allen, 1914), buffle-head (Munro, 1942) and other species, and very likely contributed to the apparent sex-ratio variation in the common golden-eye, buffle-head and common merganser in our study. Although juvenile males of these species were separated whenever possible, some were probably confused with females. For this reason the sex ratios presented for these species during the period February 15 to March 28 are considered most accurate.

An alternate explanation for the seasonal variations in sex ratios concerns a differential migratory behavior between paired and unpaired birds. Hochbaum (1944) mentioned that paired canvas-backs arrive at Delta marsh before the unpaired birds; this would tend to result in an increased proportion of males in later sex counts. Beer (1945) noted that paired baldpates were the first to depart from wintering grounds in southwestern Washington, and McIlhenny (1940) observed that female blue-winged teal began migrating north as soon as they were paired. A later preponderance of males was observed in the study area in the case of the ruddy duck. However, observations of the redhead indicated that most wintering birds and early migrants were not paired, and later

flocks were composed largely of paired birds. Fuller (1953) noted a similar situation with migrating pintail in Utah.

It is therefore apparent that any general statement to the effect that paired birds migrate earlier or faster than unpaired birds (or vice versa) is subject to considerable debate. However, it is possible that, through the differences in habitat preferences by paired vs. unpaired birds, sufficient cleavage of migratory routes in these two components of the populations occurs to account for paired (or unpaired) birds arriving at a particular location first. If such an influence is actually operative, it would appear logical to suspect that unpaired birds would tend to select habitats suitable for courtship but unsuited for breeding, whereas paired birds would go directly to breeding areas and other habitats that offer most opportunities for food and shelter.

In all likelihood no single explanation will suffice; it is highly probable that all of the above complexities enter into the variations usually encountered in waterfowl sex-ratio counts. As a means of summarizing and comparing some of the available data on sex ratios, ratios observed in this study are compared with samples obtained by direct count in other areas (Table 3). Although ratios based on larger samples obtained from banding and hunter-kill data are available for

TABLE 3.—A COMPARISON OF NORTH AMERICAN WATERFOWL SEX RATIOS

| Species | Sex Ratio | Location | Source |
|---|---|---|---|
| Mallard | 131:100 (5,014) | Washington | Present Paper |
| | 126:100 (6,810) | Ore., Calif., Nev. | Evenden (1952) |
| | 109:100 (8,805) | Washington | Yocom (1949) |
| Gadwall | 109:100 (510) | Washington | Present Paper |
| | 101:100 (271) | Ore., Nev., Ariz. | Evenden (1952) |
| Baldpate | 140:100 (851) | Washington | Present Paper |
| | 114:100 (4,999) | Washington | Beer (1945) |
| Pintail | 126:100 (1,035) | Washington | Present Paper |
| | 126:100 (12,336) | District of Columbia | Petrides (1944) |
| | 133:100 (11,687) | Utah | Fuller (1953) |
| Green-winged Teal | 114:100 (869) | Washington | Present Paper |
| | 108:100 (4,264) | British Columbia | Munro (1949) |
| Blue-winged Teal | 144:100 (5,090) | Iowa | Bennett (1938) |
| Cinnamon Teal | 97:100 (114) | Washington | Present Paper |
| | 87:100 (2,379) | Utah | Spencer (1953) |
| Shoveller | 141:100 (277) | Washington | Present Paper |
| | 152:100 (3,190) | Ore., Calif., Nev. | Evenden (1952) |
| Redhead | 152:100 (613) | Washington | Present Paper |
| | 142:100 (3,400) | Iowa | Low (1945) |
| Ring-necked Duck | 163:100 (481) | Washington | Present Paper |
| | 193:100 (1,495) | Wisconsin | Buss & Mattison (1955) |
| Canvas-back | 404:100 (580) | Washington | Present Paper |
| | 162:100 (8,936) | Minnesota | Smith (1946) |
| Lesser Scaup | 305:100 (580) | Washington | Present Paper |
| | 201:100 (10,664) | Manitoba | Sowls (1955) |
| Common Golden-eye | 116:100 (859) | Washington | Present Paper |
| | 141:100 (140) | Minnesota | Erickson (1943) |
| Buffle-head | 89:100 (484) | Washington | Present Paper |
| | 142:100 (384) | British Columbia | Munro (1942) |
| | 158:100 (520) | Iowa | Low (1941) |
| Ruddy Duck | 142:100 (1,038) | Washington | Present Paper |
| | 141:100 (850) | Iowa | Low (1941) |
| Common Merganser | 161:100 (615) | Washington | Present Paper |
| | 138:100 (773) | Washington | Beer (1945) |

some of these species, such ratios have been shown to produce biased results (Petrides, 1944; Yocom, 1949). Thus, with the exception of Bennett's (1938) data (which are based partially on hunter-kill), the samples included are the largest available based on direct counts.

## ACKNOWLEDGMENTS

These data were obtained as part of a research project sponsored by the State College of Washington and the State of Washington Department of Game. The project was financed in part by funds provided for biological and medical research by the State of Washington Initiative Measure No. 171.

## SUMMARY

During the spring of 1954, sex-ratio studies were conducted in the Potholes area, Grant County, central Washington. Data were collected on over 15,000 ducks, including 17 species. Sex ratios during any single period were found to vary as a result of different habitat preferences and tolerance of disturbance between paired and unpaired birds. Changes in sex ratios as the migration period progressed were attributed to be the probable result of a differential migratory behavior between ages, sexes, and paired vs. unpaired birds.

## LITERATURE CITED

ALLEN, A. A. 1914. The red-winged blackbird: a study in the ecology of a cat-tail marsh. Abst. Proc. Linn. Soc. N. Y., No. 24-25: 43-128.

BEER, J. R. 1945. Sex ratios of ducks in southwestern Washington. Auk, 62:117-124.

BENNETT, L. J. 1938. The blue-winged teal, its ecology and management. Collegiate Press Inc., Ames, Iowa. 144 pp.

BRETZ, J. H. 1928. The channeled scablands of eastern Washington. Geog. Rev., 18:446-477.

BUSS, I. O. AND H. M. MATTISON. 1955. A half century of change in bird populations of the lower Chippewa River, Wisconsin. Milwaukee Public Museum, Milwaukee. 319 pp.

ERICKSON, A. B. 1943. Sex ratios of ducks in Minnesota, 1938-1940. Auk, 60:20-34.

EVENDEN, F. G., JR. 1952. Waterfowl sex ratios observed in the western United States. Jour. Wildl. Mgt., 16:391-393.

FULLER, R. W. 1953. Studies in the life history and ecology of the American pintail (*Anas acuta tzitizhoa* Vieillot) in Utah. M.S. thesis, Utah State Agricultural College, Logan. 181 pp.

HARRISON, J. AND A. MCLEAN. 1947. The effect of severe weather on wigeon. Brit. Birds, 40:218.

HOCHBAUM, H. A. 1944. The canvasback on a prairie marsh. American Wildlife Institute, Washington, D.C. 201 pp.

JOHNSGARD, P. A. 1954. Birds observed in the Potholes region during 1953-54. Murrelet, 35(2): 25-31.

———. 1955. Courtship activities of the Anatidae in eastern Washington. Condor, 57(1):19-27.

———. 1956. The effects of water fluctuation and vegetation change on bird populations, particularly waterfowl. Ecology (in press).

LEBRET, T. 1950. The sex ratios and the proportion of adult drakes of teal, pintail, shoveler and wigeon in the Netherlands, based on field counts made during autumn, winter, and spring. Ardea, 38(1-2):1-18.

LEOPOLD, A. 1919. Differential sex migration of mallards in New Mexico. Condor, 21:182-183.

LOW, J. B. 1941. Spring flight of the diving ducks through northwestern Iowa. Condor, 43(3): 142-151.

———. 1945. Ecology and management of the redhead, *Nyroca americana*, in Iowa. Ecol. Mong., 15(1):35-69.

MCILHENNY, E. A. 1940. Sex ratio in wild birds, Auk, 57(1):85-93.

MUNRO, J. A. 1942. Studies of waterfowl in British Columbia. Bufflehead. Canad. J. Res., 20(D): 133-160.

———. 1949. Studies of waterfowl in British Columbia. Green-winged teal. Canad. J. Res., 27 (D):149-178.

NICE, M. M. 1937. Studies in the life history of the song sparrow (I). Trans. Linn. Soc. N.Y., 4:1-247.

PETRIDES, G. A. 1944. Sex ratios in ducks. Auk, 61:564-571.

SMITH, J. D. 1946. The canvas-back in Minnesota. Auk, 63:73-81.

SOWLS, L. K. 1955. Prairie ducks: a study of their behavior, ecology and management. Wildlife Management Institute, Washington, D. C. 193 pp.

SPENCER, H. F. 1953. The cinnamon teal (*Anas cyanoptera* Vieillot): its life history, ecology, and management. M.S. thesis, Utah State Agric. Coll., Logan. 184 pp.

STOUT, R., A. SOLBERG, K. BRAGET, J. PACE AND R. WALLACE. 1955. Waterfowl study on the Snake River. Unpublished report filed in Dept. Zoology, State Coll. of Wash., Pullman.

TINBERGEN, N. 1939. The behavior of the snow bunting in spring. Trans. Linn. Soc. N. Y., 5:1-94.

YOCOM, C. F. 1949. A study of sex ratios of mallards in the state of Washington. Condor, 51: 222-227.

Received for publication August 2, 1955.

# RECLAMATION OF POTENTIAL TROUT PONDS IN MAINE

*Robert E. Foye*[1]

Maine Department of Inland Fisheries and Game, Augusta, Maine

Pond reclamation has progressed slowly in Maine since the introduction of rotenone compounds in the early 1930's for the control of undesirable species. This is understandable since many of Maine's 2,500 lakes and ponds are natural trout ponds which contain thriving populations of eastern brook trout (*Salvelinus fontinalis*).

Sabbathday Lake in Cumberland County, which was treated by Cooper (1939), was the first Maine lake, and one of the first large lakes in the United States to be reclaimed. Only two additional ponds in Maine were reclaimed prior to 1951. No accurate data are available concerning the results of the reclamation of these ponds, but general observations indicate that successful trout fishing was established in these waters although undesirable fishes are known to have reappeared in one.

A study entitled "Reclamation of Potential Trout Ponds," Dingell-Johnson Project F-6-R, was begun in 1951 by the Fishery Research and Management Division of the Maine Department of Inland Fisheries and Game. This study has provided information heretofore lacking regarding this type of fishery management in Maine, and results should be of value in selecting additional ponds for reclamation. Ponds reclaimed as a result of this study have already provided recreation to hundreds of trout fishermen.

## Selection and Description of Ponds

Five small ponds with pronounced differences in their physical and chemical characteristics were initially chosen for the study. Two additional ponds were treated with rotenone to prevent the reintroduction of undesirable fishes into the study ponds during periods of high water. These additional two ponds are omitted from the sections of this paper that pertain to stocking and creel censuses.

Ponds selected for reclamation were chosen from a group of 14 (Fig. 1) commonly known as the Summer Haven Chain of ponds located in the towns of Sidney, Manchester, and Belgrade in Kennebec County. Pond areas ranged from 6 to 29 acres. These kettle-type ponds of glacial origin are separated from each other by steep gravel ridges. The surrounding heavily wooded area is composed of mixed hardwoods interspersed with pine and hemlock on the higher elevations. Spruce-bog growth occurs in the lower elevations. The ponds are further characterized by the absence of inlets and outlets except during seasonal periods of high water when small, shallow thoroughfares join several of the ponds in the group.

The reclaimed ponds have maximum depths that range from 24 to 70 feet and average depths that range from 13 to 25 feet. All ponds exhibit thermal stratification. The depths above which dissolved oxygen remains more than 3 ppm during the critical summer period range from 10 to 40 feet among individual waters.

A variety of bottom types are represented in the several ponds. Extensive areas of sand, gravel, and fine rubble are found in the littoral zones of five ponds. The entire bottom areas of two ponds are covered by deep layers of peat and muck. Aquatic vegetation, relatively scarce in all ponds, is confined mostly to the muck-bottomed coves.

The 10 species of fish removed from the reclaimed ponds were: white sucker (*Catostomus commersoni*), golden shiner (*Notemigonus crysoleucas*), brown bullhead (*Ameiurus nebulosus*), chain pickerel (*Esox niger*), ninespine stickleback (*Pungitius pungitius*), yellow perch (*Perca flavescens*), yellow walleye (*Stizostedion vitreum*), largemouth bass (*Micropterus salmoides*),

[1] The writer wishes to acknowledge the following persons for their assistance in conducting the study: Dr. W. Harry Everhart and Lyndon H. Bond for their guidance and supervision; members of the Fishery Research and Management Division and the Inland Fisheries and Game Warden Service for their assistance in the field work; the Hatchery Division of the Maine Department of Inland Fisheries and Game for making hatchery stock available; the Federal Aid in Fish Restoration Act for finances; and the many sportsmen who willingly assisted in the collection of field data.

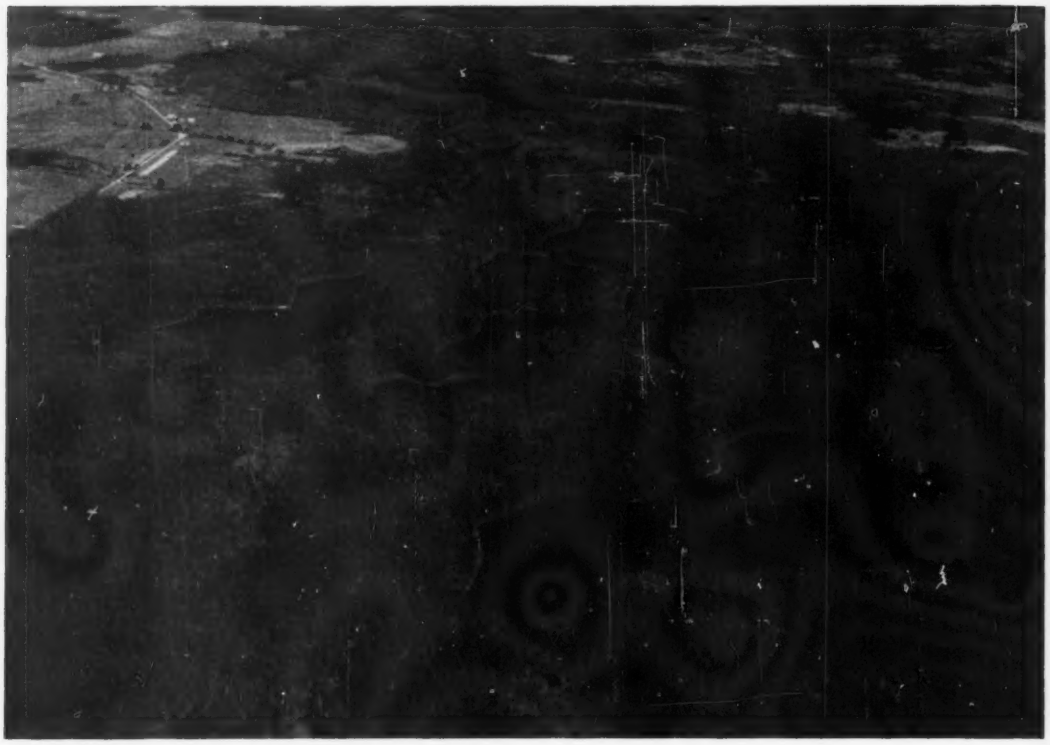


FIG. 1. Summer Haven Chain of ponds.

pumpkinseed sunfish (*Lepomis gibbosus*), and white perch (*Morone americana*). No individual pond contained all species.

## RECLAMATION

*Toxicants and Concentrations.* — The ponds were chemically treated during the summer of 1951 with Noxfish, an emulsifiable rotenone product of five per cent concentration, and Fish-Tox. Noxfish is distributed by S. B. Penick Company, New York, New York, and Fish-Tox by Standard Supply Distributors, Wenatchee, Washington.

Two ponds were treated with Fish-Tox and later re-treated with Noxfish to test the effectiveness of the Fish-Tox. A complete kill apparently resulted in both ponds from the initial treatment with Fish-Tox. No fish were removed after the second treatment. Rough fishes have not reappeared in either pond. The other five ponds were reclaimed with Noxfish.

Most ponds received 0.5 ppm concentration plus an additional 10 per cent as a safety precaution. In order to determine the effectiveness of different concentrations of rotenone, Emery Pond was initially treated with a concentration of 0.25 ppm of Noxfish and later re-treated with a concentration of 0.5 ppm. An additional 10 per cent was added in each instance. The initial treatment of Emery Pond with a concentration of 0.25 ppm of Noxfish was unsuccessful in obtaining a complete kill of pumpkinseed sunfish and ninespine sticklebacks. The follow-up application at a concentration of 0.5 ppm of Noxfish was also unsuccessful. Studies of the vertical distribution of toxicants and associated studies to determine proper techniques for the dispersal of toxicants indicated that failure to obtain a complete kill in Emery Pond was probably the result of improper treatment of the deeper sections of the pond. The same may be said of Tyler Pond, the only other pond where a known incomplete kill of rough fishes occurred.

Undesirable fish have not reappeared in other ponds in the study. A complete kill is indicated in these ponds.

*Application.*—Application methods varied with the toxicant used and the physical features of the area being treated.

Fish-Tox is packed in semipaste form in 50-pound burlap bags. The burlap bags are adaptable for dragging behind boats, and most of the Fish-Tox was applied in this manner. A small quantity of Fish-Tox was dissolved in water and sprayed from hand pumps over shallow weedy areas. Treatment of deep areas with Fish-Tox was facilitated by reducing the speed of the boat to allow the bags of Fish-Tox to sink. A slight jigging motion facilitated dispersal.

Noxfish was diluted with water and the mixture applied by a small gas-operated piston-type pump or by hand pumps. Hand pumps were often employed for spraying shallow weedy areas. A long weighted hose was used to distribute Noxfish in the deeper waters of Figure Eight Pond. This method is considered satisfactory for treating deep areas.

*Estimates of Fish Kills.*—Fyke nets were utilized in Wellman and Emery ponds for several days prior to their reclamation. Fish captured were fin-clipped and released. Sufficient numbers of fish were netted and marked in both ponds prior to reclamation to permit estimates of the total numbers killed. A record was kept of all marked and unmarked fish recovered following the treatment with rotenone.

An estimated 176 chain pickerel and 1,439 brown bullheads were removed from Wellman Pond. An estimated total of 5,261 pumpkinseed sunfish was recovered from Emery Pond. Estimates of error for the five per cent limit of probability for chain pickerel were 93-335; for brown bullheads, 1,107-1,764; and for pumpkinseed sunfish, 4,775-5,804.

Recoveries of 39 per cent of marked pickerel and 29 per cent of marked bullheads were made at Wellman Pond. At Emery Pond 27 per cent of marked pumpkinseed sunfish were recovered. Ball (1948) recovered 58.9 per cent of marked bluegills and 44.7 per cent of marked trout from a 10.7-acre lake in Michigan. Carlander and Lewis (1948) reported the following recovery of marked fish from a 0.3-acre pond in Iowa: bluegill (*Lepomis macrochirus*), 38 per cent; white crappie (*Pomoxis annularis*), 14 per cent; largemouth bass, 33 per cent; black bullhead (*Ameiurus melas*), 80 per cent; and golden shiner, 91 per cent. Considerable numbers of dead fish were observed on the bottom of all ponds treated during this study. Many of these could not be recovered.

The general small size of fish removed from the several ponds together with age and growth studies indicated overpopulations of several species.

*Vertical Distribution of Toxicants.*—Vertical distribution of toxicants was measured by the conventional use of wire cages that contained small fish. The cages were suspended at different levels in each pond prior to reclamation and contained either banded killifish (*Fundulus diaphanus*), brown bullheads, yellow perch, or pumpkinseed sunfish. A maximum depth penetration of only 15 feet was obtained from the surface application of Noxfish. Fish-Tox, dragged slowly behind boats over deep-water areas, resulted in toxic concentrations to 25 feet.

The thermocline was a definite barrier to the vertical distribution of both Noxfish and Fish-Tox. Krumholz (1948), Clemens and Martin (1952), and others have shown the thermocline to impede rotenone distribution seriously. Proper treatment of waters in and below the thermocline cannot be expected unless toxicants are pumped directly into these strata. Successful treatment of the depths of Figure Eight Pond was apparently the result of pumping Noxfish into the deep waters.

*Dissipation of Toxicants.*—The length of time that elapsed between the treatment and detoxication was dependent upon several factors which include physical and chemical characteristics of individual waters, time of reclamation (season), species of fish involved, and toxicant concentrations.

Studies were made throughout the summer and fall of 1951 to determine the periods of toxicity to fish life. Most ponds remained toxic to brook trout for periods of two to three months, although exact times were not determined.

Zilliox (1954), in a study of several ponds reclaimed in the State of New York, found that four out of five ponds had lost their toxicity within 54 days after reclamation. Toxicity tests in these ponds were applicable to brook trout only and indicated that more resistant species such as bullheads and suckers

could probably tolerate waters toxic to brook trout. In a study of 30 Oklahoma farm ponds Clemens and Martin (*op. cit.*), using minnows for test purposes, found that emulsifiable rotenone dissipated in much shorter periods.

## STOCKING

Ponds were stocked initially in the spring of 1952. Additional plantings were made in the fall of 1952 and 1953. Eastern brook trout were stocked in Figure Eight, Tyler, Chamberlain, and Emery ponds. Brown trout (*Salmo trutta*) were introduced into Gould Pond.

Trout were stocked at the rate of approximately 100 fish per surface acre. To provide immediate returns to anglers, legal-sized brook trout (minimum length of eight inches) were stocked in the spring of 1952 in the ratio of one legal-sized trout to two fingerling trout. Fall stockings were made at approximately the same ratio. Only legal-sized brown trout were stocked in the spring of 1952. Fingerling stock was unavailable at that time. Fall stockings of brown trout in 1952 and 1953 included both fingerlings and legal-sized fish.

All trout were marked by fin-clipping for future identification of the several age groups represented in the three plantings. Fish were anesthetized with urethane before marking to permit careful handling. Length and weight data were collected from a five per cent random sample of each age group.

## FISHING REGULATIONS

The following fishing regulations were in effect during the study.

*Seasons.*—The open-water fishing season began on April 1 in ponds with waters free, or partially free, of ice and closed on September 30.

Ice fishing was allowed at Gould and Emery ponds during the months of February and March. Other ponds were closed to ice fishing.

*Daily Creel Limits.*—A daily creel limit corresponding to the state-wide general daily limit of 15 trout, not to exceed 7½ pounds in any one day, was established at Figure Eight and Tyler ponds. Other ponds were regulated by a daily limit of 5 trout. The daily 15-trout limit at Figure Eight and Tyler ponds was reduced to 5 trout in 1953.

*Minimum Length Limits.*—The minimum length limit for trout was made to conform with the then general state law of 8 inches on lakes and ponds. The minimum legal length for trout in all Maine waters was reduced to 6 inches in 1955.

*Fly Fishing.*—Tyler Pond was restricted to fly fishing. Other ponds were regulated by the general state law that permits the use of natural and artificial lures.

## CREEL CENSUSES

*Open-water Fishing.*—Creel censuses were conducted during the spring months of 1952, 1953, and 1954 when optimum fishing conditions for trout occur. Data collected during the several weeks of spring fishing are considered to be representative for comparing the results from the several reclaimed ponds.

The spring census in 1952 began immediately after the initial stocking of trout and terminated on June 14. The 1953 and 1954 spring creel checks began at the start of spring fishing and terminated at the end of May. In 1953 all ponds were sufficiently clear of ice on April 1 to permit angling. In 1954 open-water angling commenced on different days at the several ponds due to differences in ice conditions prevailing after April 1.

Creel data collected during the spring of 1952, 1953, and 1954 are summarized in Table 1.

Data collected from Tyler and Figure Eight ponds with daily limits of 15 trout during 1952 indicated the need for a lower limit on small, heavily fished brook trout ponds. In 1952 at Tyler Pond, 18 fishermen, 15 per cent of the total number of fishermen interviewed, creeled 174 brook trout, which represented 56 per cent of the total catch during the census period. During the same period at Figure Eight Pond 27 fishermen, 10 per cent of the fishermen interviewed, creeled 217 brook trout or 38 per cent of the total catch during the census period. Fishermen angling for brown trout in Gould Pond during the same period were much less successful in taking their daily limit. Only two fishermen in 1952 were successful in taking their daily limit of 5 brown trout.

In the spring of 1953 only 12 of the 908 fishermen at Gould Pond caught their limit of 5 brown trout, and in 1954 only 18 of the

TABLE 1. – SPRING CREEL CENSUS DATA FOR FIVE MAINE PONDS FOR 1952, 1953, AND 1954.

| Pond | Number of Days Censused | Number of Fishermen Visits | Number of Parties | Number of Successful Parties | Total Line Hours Fished | Total Trout Creeled | Catch per Line Hour |
|---|---|---|---|---|---|---|---|
| Tyler | | | | | | | |
| 1952 | 26 | 117 | 65 | 48 | 305 | 312 | 1.0 |
| 1953 | 60 | 424 | 242 | 153 | 973 | 691 | 0.7 |
| 1954 | 41 | 177 | 113 | 51 | 369 | 177 | 0.5 |
| Figure Eight | | | | | | | |
| 1952 | 26 | 258 | 128 | 100 | 610 | 570 | 0.9 |
| 1953 | 60 | 1,361 | 671 | 288 | 2,813 | 1,159 | 0.4 |
| 1954 | 53 | 1,166 | 591 | 285 | 2,510 | 1,236[1] | 0.5 |
| Emery | | | | | | | |
| 1952 | 26 | 59 | 23 | 20 | 110 | 162 | 1.5 |
| 1953 | 60 | 106 | 55 | 7 | 136 | 10 | 0.1 |
| 1954 | 48 | 76 | 40 | 2 | 112 | 5 | 0.04 |
| Chamberlain | | | | | | | |
| 1952 | 26 | 27 | 15 | 13 | 55 | 74 | 1.3 |
| 1953 | 60 | 121 | 61 | 31 | 328 | 93 | 0.3 |
| 1954 | 44 | 113 | 61 | 38 | 275 | 153[2] | 0.6 |
| Gould | | | | | | | |
| 1952 | 50 | 280 | 142 | 57 | 631 | 165 | 0.3 |
| 1953 | 60 | 908 | 488 | 159 | 2,167 | 384 | 0.2 |
| 1954 | 43 | 954 | 528 | 181 | 2,406 | 456 | 0.2 |

[1] Includes 19 naturally produced trout
[2] Includes 1 naturally produced trout

954 fishermen caught their limit. These findings indicate that a limit of 5 brown trout is unnecessary for obtaining better distribution of the catch.

In 1953 the daily creel limits of brook trout at Figure Eight and Tyler ponds were reduced from 15 to 5 fish. In spite of the reduced limit, fishermen at Tyler Pond harvested 49 per cent of the total catch recorded during the first 10 days of the entire 1953 spring checking period. Likewise, fishermen at Figure Eight Pond during the first 10 days of the 1953 fishing season harvested 84 per cent of the total catch recorded during the entire spring checking period. The 5-trout limit nevertheless resulted in better distribution of the catch, and even though a large percentage of the total catch from Tyler and Figure Eight ponds occurred during the first 10 days of spring fishing, this period of good fishing would undoubtedly have been of shorter duration had the limit been allowed to remain at 15 fish.

Data obtained in 1954 from Figure Eight Pond were similar to 1953 data, when fishermen again harvested a large percentage of the total spring catch during the first 10 days of fishing.

Fly fishermen were generally as successful in taking brook trout as bait fishermen. Throughout the study, catch-per-line-hour figures for Tyler Pond, where fishermen were restricted to flies, were generally as high or higher than comparable figures for other brook trout ponds in the study. Seventy-three per cent of the spring catch of brown trout in 1952 at Gould Pond was made on artificial flies by 36 per cent of the anglers. In 1953 at Gould Pond 16 per cent of the fishermen took 38 per cent of the total catch of brown trout on flies, and in 1954, 36 per cent of the total catch was taken on flies by 10 per cent of the anglers.

Total numbers and percentages of stocked trout creeled during the spring census periods are presented in Table 2. The percentage composition of age groups represented in the spring open-water catches for all ponds for 1953 and 1954 are given in Table 3. It is evident that a large percentage of brook trout are lost to the fishery before they reach three years of age. These data agree with similar findings of other fishery workers.

A slightly greater number of three-year-old brook trout were creeled in 1953 and 1954 from Tyler Pond than from other ponds. A larger carry-over of trout from age group

TABLE 2. — TOTAL NUMBER OF TROUT CREELED IN FIVE MAINE PONDS. (THE PERCENTAGE RETURNS OF STOCKED FISH ARE IN PARENTHESES.)

| Pond | Time Caught | Year Class and Time Stocked | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1949 Spring '52 | 1950 Spring '52 | 1950 Fall '52 | 1931 Fall '52 | 1951 Fall '53 | Not determined[1] | Total |
| Tyler | 1952 | 282 (49) | 30 (3) | — | — | — | 0 (0) | 312 |
| | 1953 | 46 (8) | 289 (27) | 302 (53) | 0 (0) | — | 54 (2) | 691 |
| | 1954 | 0 (0) | 19 (2) | 0 (0) | 30 (3) | 100 (17) | 28 (1) | 177 |
| | Total | 328 (57) | 338 (31) | 302 (53) | 30 (3) | 100 (17) | 82 (2) | 1,180 |
| Figure Eight | 1952 | 496 (51) | 72 (4) | — | — | — | 0 (0) | 568 |
| | 1953 | 27 (3) | 297 (16) | 757 (67) | 32 (1) | — | 46 (1) | 1,159 |
| | 1954 | 0 (0) | 7 (0.4) | 7 (1) | 460 (19) | 717 (72) | 26 (0.4) | 1,217 |
| | Total | 523 (53) | 376 (20) | 764 (68) | 492 (21) | 717 (72) | 72 (1) | 2,944 |
| Emery | 1952 | 146 (52) | 16 (3) | — | — | — | 0 (0) | 162 |
| | 1953 | 0 (0) | 4 (1) | 6 (2) | 0 (0) | — | 0 (0) | 10 |
| | 1954 | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (1) | 1 (0.3) | 5 |
| | Total | 146 (52) | 20 (4) | 6 (2) | 0 (0) | 4 (1) | 1 (0.05) | 177 |
| Chamberlain | 1952 | 69 (34) | 5 (1) | — | — | — | 0 (0) | 74 |
| | 1953 | 0 (0) | 5 (1) | 76 (38) | 6 (2) | — | 6 (1) | 93 |
| | 1954 | 0 (0) | 0 (0) | 0 (0) | 45 (11) | 27 (14) | 80 (13) | 152 |
| | Total | 69 (34) | 10 (3) | 76 (38) | 51 (13) | 27 (14) | 86 (6) | 319 |
| Gould | 1952 | 165 (13) | — | — | — | — | 0 (0) | 165 |
| | 1953 | 200 (16) | — | 167 (17) | 0 (0) | — | 17 (1) | 384 |
| | 1954 | 27 (2) | — | 62 (6) | 197 (16) | 104 (16) | 66 (1) | 456 |
| | Total | 392 (31) | — | 229 (23) | 197 (16) | 104 (16) | 83 (2) | 1,005 |

[1] Catch reported by anglers but not personally inspected by Fishery Division personnel to interpret marks.

II to age group III in Tyler Pond was probably the result of the inability of most anglers to harvest trout in Tyler Pond during the summer months by fly fishing. However, the carry-over in terms of numbers of three-year-olds creeled in 1953 at Tyler Pond was less than 10 per cent of the total number of that brood year stocked. In 1954 the carry-over of three-year fish was less than two per cent of the total number stocked of that particular brood year.

The fly-fishing law at Tyler Pond cannot

TABLE 3. – AGE GROUPS TAKEN BY ANGLERS IN 1953, 1954

| Age Group | | Per Cent of Total Catch | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | Undetermined |
| Brook trout | (1953) | 4 | 87 | 4 | 0 | 5 |
| | (1954) | 1 | 89 | 2 | 0 | 8 |
| Brown trout | (1953) | 0 | 44 | 52 | – | 4 |
| | (1954) | 0 | 66 | 14 | 6 | 14 |

be justified on the basis of a few more age group III trout in the catch. The same reasoning may apply to other similar ponds restricted to fly fishing only. Tyler Pond trout of age group III were not significantly larger than those in age group II. This is important and should be considered along with other reasons for removing the fly-fishing regulations at Tyler Pond. The ability of fly fishermen to catch trout as successfully as do other types of anglers has already been mentioned, and removal of the fly-fishing law at Tyler Pond should be considered.

Observations made at Gould Pond in the summer months during the investigation showed considerable surface feeding by brown trout. Fishermen were attracted to Gould Pond in large numbers during the warm, summer months primarily as a result of the visible display of brown trout feeding at the surface. However, only small catches of brown trout were reported by fishermen during the summer months.

Analysis of data collected during the 1954 spring creel census revealed that 87 per cent of the fishing parties visiting the several reclaimed ponds resided within a 15-mile radius. Most of the remaining 13 per cent resided within 30 miles. All of the reclaimed ponds are within 8 miles of the city of Augusta, which has a population of approximately 21,000.

*Ice Fishing.*—Ice-fishing censuses were conducted at Gould and Emery ponds during the months of February and March in 1953 and 1954. Table 4 contains ice-fishing creel census data for the 1953 and 1954 ice-fishing seasons.

The inability of ice fishermen to harvest brown trout in large numbers is indicated by the small harvests of brown trout from Gould Pond during both years. A catch of 3 brown trout by ice fishermen in 1953 and 16 brown trout in 1954 is insignificant when compared to harvests of 384 brown trout in the spring of 1953 and 456 brown trout in the spring of 1954 by open-water anglers.

Similar findings were made by DeRoche and Bond (1952), and by Fenderson (1953) at Branch Lake, Hancock County, Maine.

Ice fishermen who angled for brook trout in Emery Pond were more successful than those who angled for brown trout at Gould Pond. Total catches of brook trout in 1953 and 1954 by ice fishermen at Emery Pond were still relatively small in terms of numbers stocked. Catch rates were correspondingly low. It is important, however, to point out that, although the total harvests of brook trout from Emery Pond by ice fishermen were small in both years, they nevertheless made up 80 and 91 per cent, respectively, of the total combined open-water and winter catches for 1953 and 1954. Spring catches of brook trout at Emery Pond in 1953 and 1954

TABLE 4. – ICE-FISHING CREEL CENSUS DATA FOR 1953 AND 1954

| Pond | Emery[1] | | Gould[2] | |
|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 |
| Number of days censused | 46 | 32 | 46 | 32 |
| Number of fishermen visits | 111 | 145 | 106 | 114 |
| Number of parties | 44 | 61 | 39 | 48 |
| Number of successful parties | 19 | 24 | 3 | 13 |
| Per cent of successful parties | 43 | 39 | 8 | 27 |
| Number of lines fished | 475 | 673 | 420 | 493 |
| Total line hours fished | 2,202 | 3,163 | 1,856 | 2,026 |
| Average number of lines per fisherman | 4.3 | 4.6 | 4.0 | 4.3 |
| Number of trout caught[3] | | | | |
| 1949 year class (Spring, 1952) | 3 | 0 | 3 | 5 |
| 1950 Year class (Spring, 1952) | 15 | 3 | — | — |
| 1950 year class Fall, 1952) | 33 | 0 | 0 | 7 |
| 1951 year class (Fall, 1952) | 0 | 1 | 0 | 4 |
| 1951 year class (Fall, 1953) | — | 51 | — | 0 |
| Total catch | 41 | 55 | 3 | 16 |
| Catch per line hour | .019 | .017 | .002 | .008 |
| Average catch per hour per fisherman[4] | .082 | .078 | .008 | .034 |
| Average number fishermen hours per trout | 12 | 12 | 155 | 29 |

[1] Stocked with brook trout
[2] Stocked with brown trout
[3] Stocking time in parentheses
[4] Catch per line hour times the average number of lines per fisherman

were small. Relatively heavy winter mortality in Emery Pond is indicated.

## GROWTH OF TROUT

Trout grew at a normal rate in all but one of the reclaimed ponds. Growth of both brook trout and brown trout in the reclaimed ponds was similar to that of many other Maine lakes (Rupp, 1954). Significant differences were found to exist in the growth rates of brook trout of certain year classes between individual ponds. The difference between the average total lengths of brook trout from all ponds of age group II, which made up a large percentage of the brook trout creeled, was 3.1 inches (range 8.2 to 11.3 inches). By disregarding growth data of trout from Tyler Pond, where growth was retarded by severe competition of undesirable fishes, this difference was reduced to less than two inches.

Total lengths at time of capture of brook trout stocked as fingerlings in reclaimed ponds nearly equaled that of trout of the same age group held in the hatchery an additional year and then stocked as legal-sized fish. More important, brook trout stocked as fingerlings were usually significantly heavier than trout of the same age group stocked as legal-sized fish.

In several instances a loss in weight occurred during the winter months in trout stocked as legal-sized fish. The high rate of survival of fingerling trout stocked in several of the reclaimed ponds and the apparent ability of fingerling trout to become better acclimated to natural conditions than trout stocked at legal size, certainly favor the stocking of fingerling trout in reclaimed ponds. The added cost of raising trout to legal size should also be considered.

The survival of future stockings of fingerling brown trout in Gould Pond may become increasingly less with the establishment of progressively older age groups of brown trout during the next several years. Fenderson (*op. cit.*) found that brown trout over 12 inches in total length in Branch Lake, Maine, fed on fish during all seasons. Wales (1946) found small brown trout to be an important food item of large brown trout in Castle Lake, California.

The cannibalistic tendencies of brown trout, especially in the older age groups that are likely to occur in Gould Pond, may be minimized by a continuation of the alewife (*Pomolobus pseudoharengus*) stocking program. Alewives in Gould Pond are stocked experimentally as a forage fish for the trout.

## ALEWIFE INTRODUCTIONS

Early in 1952 adult alewives were introduced into Tyler and Gould ponds. Additional plantings were made at Gould Pond in the spring of 1953 and 1954. Alewives for stocking were obtained during the spring spawning run of alewives at Damariscotta Mills, Maine.

A total of 140 adult alewives was stocked in Tyler Pond in May 1952. Gould Pond was stocked with 144 alewives in May 1952, 315 adult alewives in May 1953, and 236 adult fish in the spring of 1954.

Studies were undertaken to determine the importance of small alewives as forage fish for trout in small reclaimed ponds, and to provide information on the life histories of sea-run alewives introduced into small landlocked ponds.

Havey (1952) found salmon (*Salmo salar*) feeding on the young of sea-run alewives at Long Pond, Mount Desert Island, Maine. Odell (1935) mentioned the importance of landlocked alewives as food for lake trout (*Cristivomer namaycush*) and other fishes in the Finger Lakes, New York. The landlocked alewife is also listed as an important food of smallmouth bass (*Micropterus dolomieui*) in Cayuga Lake, New York (Webster, 1954).

Food studies were undertaken at both ponds in 1952 and at Gould Pond in 1953. Stomachs of brook trout from Tyler Pond and brown trout from Gould Pond were examined to determine food types and their abundance both numerically and volumetrically.

In 1952, 46 brook trout stomachs from Tyler Pond were examined. Total lengths of fish examined ranged from 8.0 to 10.9 inches. Six stomachs contained alewives. Small alewives comprised 19.2 per cent of the total volume of food in the 46 stomachs.

In 1953, 40 brown trout stomachs from Gould Pond were examined. Total lengths of trout examined ranged from 7.6 inches to 13.5 inches. Twelve stomachs contained alewives. Alewives comprised 44 per cent of the total volume of food in the 40 stomachs.

During the summer of 1952, schools of young alewives were observed along the

shore lines of both ponds. Schools of small alewives were observed throughout the fall months until the ponds were frozen over. In the spring of 1953, alewives were not seen in either pond, and nets failed to show their presence. Similar findings were made in 1954.

Introductions of sea-run alewives as forage fish in ponds intensively managed for trout have important aspects, especially in areas where sources of alewives occur close by. The ability of a few dozen adult alewives to produce very large numbers of young early in the growing season and the specialized feeding habits of alewives, which made them unimportant from the standpoint of competition with the trout, are important factors to be considered. Present findings indicate that the presence of alewives may result in a greater survival of fingerling brown trout by serving as a buffer food for the larger fish in the pond.

## SHORE SPAWNING OF BROOK TROUT

Studies were undertaken to determine the extent of shore spawning of brook trout in the several ponds, and to obtain information on the relative success of shore spawning in terms of the numbers of legal-sized trout contributed to the fishery.

Brook trout were first observed spawning in Figure Eight Pond on October 20, 1952, and in Tyler and Chamberlain ponds shortly thereafter. Spawning activities extended into the early part of December. Trout were not observed spawning in other ponds. Spawning occurred in a variety of bottom types that ranged from fine sand to fine gravel. Redds in Figure Eight Pond were numerous all along the eastern and northern shores.

Brook trout spawning in sandy-bottom types often exposed underlying gravel in which they deposited their eggs. Spawning was so frequent in Figure Eight Pond in such a wide range of bottom types that it suggested little individual preference in the selection of spawning sites. Correlation between the location of redds and areas of spring seepage was not accurately determined.

During the fall of 1953, brook trout were again observed spawning in Tyler, Figure Eight, and Chamberlain ponds. Many of the redds found in 1953 in Figure Eight Pond, particularly in sandy areas, were completely filled in and destroyed by sand from bottom disturbances caused by excessive wave action that fall.

Shore spawning at Chamberlain Pond was confined mostly to the gravel areas along the eastern shore. Four redds were observed in Chamberlain Pond in the fall of 1952 and five in the fall of 1953.

Following the clearing of ice in the spring of 1953, the shores of all ponds were inspected for trout fry. On April 8, several brook trout fry were observed close to shore in a shallow cove in Figure Eight Pond. Further observations revealed numerous fry in other sections of the pond. On April 16, brook trout fry were observed in Tyler Pond at several locations. No trout fry were seen in other ponds during 1953. Brook trout fry were observed in Figure Eight and Tyler ponds again in the spring of 1954, but they were less numerous than in the preceding year.

During the spring creel census of 1954, fishermen caught 19 shore-spawned trout from Figure Eight Pond. The average total length of these trout was slightly over the minimum eight-inch limit.

Many undersized unmarked brook trout were reported hooked by fishermen from Figure Eight Pond during the 1954 spring creel census. Since all trout stocked during the study were fin-clipped, it is assumed that these unmarked undersized trout were from the 1952 hatch of shore-spawned fish.

No unmarked brook trout were checked or reported from Tyler Pond during the 1954 spring creel census. The large numbers of yellow perch in Tyler Pond may have been responsible for a heavy mortality in the hatch of shore-spawned brook trout. It is also possible that none of the trout from the 1953 hatch were of legal size at the time of the 1954 spring creel census.

During the spring census in 1954 one unmarked trout, presumed to be of shore-spawned stock, was creeled from Chamberlain Pond. No unmarked trout were tallied or reported taken from the remaining ponds in 1954.

## SUMMARY

Seven ponds were reclaimed for trout in 1951 to furnish the detailed information necessary before utilizing this management technique in the Maine fishery program.

Ponds were selected for their different physical and chemical characteristics.

Noxfish and Fish-Tox were utilized. Studies were undertaken to determine the effectiveness of surface and deep-water treatment. Complete reclamation of undesirable fishes was obtained in two ponds treated with Fish-Tox and three ponds treated with Noxfish. Waters remained toxic for periods of two to three months following reclamation.

Five ponds were stocked with fin-clipped trout in 1952 and 1953. Four ponds were stocked with eastern brook trout; one pond with brown trout. Stocking was generally at the rate of 100 fish per surface acre. Approximately one-third of the fish stocked were of legal size.

Creel censuses of open-water fishing were conducted during the spring months of 1952, 1953, and 1954. Ice-fishing creel censuses were conducted during the 1953 and 1954 seasons. A major portion of the total spring catch of brook trout occurred during the first 10 days of the fishing season each year. The daily limit of 15 brook trout on two of the ponds in 1952 resulted in a few anglers monopolizing a large portion of the spring catch. The daily limit was reduced to 5 trout in 1953. Brown trout were more difficult to catch than brook trout and only a small number of anglers caught their limit of 5 brown trout.

Fly fishermen were generally as successful as bait fishermen in taking brook trout. A large percentage of the brown trout harvested was taken by fly fishermen during the three-year period. Ice fishermen accounted for the majority of brook trout creeled from one pond, but they took only small numbers of brown trout.

Brook trout of age group II dominated the anglers' catch. A 72 per cent recovery of brook trout from one stocking was realized from one pond. The maximum return of brook trout of age group III from any pond, expressed in terms of total catch, was 7 per cent. No brook trout of age group IV were taken by anglers. Brown trout of age groups III and IV were more often represented in the anglers' catches. Growth rates of trout in the reclaimed ponds were similar to growth rates in many other Maine lakes.

Small alewives, progeny of several hundred adult alewives of sea-run stock introduced into two ponds, were utilized as food by both brook trout and brown trout.

Successful shore spawning by brook trout occurred in three ponds. Several brook trout from shore-spawned stock were creeled in 1954.

## LITERATURE CITED


BALL, R. C. 1948. Recovery of marked fish following a second poisoning of the population in Ford Lake, Michigan. Trans. Amer. Fish. Soc., 75(1945):36-42.

CARLANDER, K. D. AND W. M. LEWIS. 1948. Some precautions in estimating fish populations. Prog. Fish-Cult., 10(3):133-137.

COOPER, GERALD P. 1939. A report on the destruction of the present fish population in Sabbathday Lake, New Gloucester Township, Cumberland County, Maine, by derris root poison. Maine Dept. Inland Fish and Game, mimeo. rept., 8 pp.

CLEMENS, HOWARD P. AND MAYO MARTIN. 1952. Effectiveness of rotenone in pond reclamation. Trans. Amer. Fish. Soc., 82(1952):166-177.

DEROCHE, STEWART E. AND LYNDON H. BOND. 1952. Ice-fishing creel census on a heavily fished trout and salmon lake. Maine Dept. Inland Fish and Game, mimeo. rept., Dingell-Johnson Project F-7-R.

FENDERSON, CARLL N. 1953. An investigation of the Branch Lake fisheries with emphasis on the brown trout (*Salmo trutta*). Masters thesis, Dept. Zool., University of Maine.

HAVEY, KEITH A. 1952. The fresh-water fishes of Long Pond and Echo Lake, Mount Desert Island, Maine. Masters thesis, Dept. Zool., University of Maine.

KRUMHOLZ, L. A. 1948. The use of rotenone in fisheries research. J. Wild. Mgmt., 12(3):305-317.

ODELL, T. T. 1935. The life history and ecological relationships of the alewife (*Pomolobus pseudoharengus* [Wilson]) in Seneca Lake, New York. Trans. Amer. Fish. Soc., 64(1934):118-124.

RUPP, ROBERT S. 1954. Age and growth of some important Maine fishes. Maine Dept. Inland Fish. and Game, mimeo. rept., 51 pp.

WALES, J. H. 1946. Castle Lake trout investigation. First phase: interrelationship of four species. Calif. Fish and Game, 32(3):109-143.

WEBSTER, D. A. 1954. Smallmouth bass, *Micropterus dolomieui*, in Cayuga Lake. Part 1. Life history and environment. Cornell University Agric. Exp. Sta. Memoir 327.

ZILLIOX, ROBERT C. 1954. Restoration of trout fishing in a chain of connected waters. N.Y. Cons. Dept., mimeo. rept., Dingell-Johnson Project F-5-R-2.


Accepted for publication March 28, 1956.

# IMPACTION AND PRESSURE NECROSIS IN CANADA GEESE DUE TO EATING DRY HULLED SOYBEANS

*A. J. Durant*

School of Veterinary Medicine, University of Missouri, Columbia

For a number of years losses from impaction and pressure necrosis in Canada geese (*Branta canadensis*) due to eating dry hulled soybeans have been observed in Missouri. The malady has been noted chiefly at the Swan Lake National Wildlife Refuge, usually between mid-October and mid-November. New cases are noted after the arrival of each new flight of geese. It is estimated that approximately one per cent of 50,000 geese have been affected annually. The acute type of impaction and death occurs shortly after the arrival of the first birds. It is estimated that from 30 to 40 per cent of the geese contracting the condition are affected with the acute type. Snow and blue geese (*Chen hyperborea* and *C. coerulescens*) that occupy the refuge at the same time are not affected, apparently because they seldom feed on, or at least do not gorge themselves on, soybeans. Observation of the phenomenon was first made by my department in the fall of 1950 by Benbrook (1950). Hanson and Smith (1950) have made some careful observations of this condition since 1943.

Attention was first drawn to the acute form of the disease by the sudden death of geese (4 to 16 hours) after drinking water when they returned from feeding in soybean fields. In the chronic form some birds recover; others linger for some time and finally die. The length of time a fatally affected bird lives probably depends on two things: (a) the degree of destruction of surrounding tissues inflicted by pressure from the swelling beans, and (b) the length of time birds will survive without food or water.

## Symptoms

Affected birds can be detected readily, and some hunters have learned to recognize and avoid shooting such birds, believing they will be unfit for food. Affected birds isolate themselves, both on the ground and in flight. Another distinguishing feature is that the goose is unable to extend its head straight forward in flight but, due to the impacted esophagus, it flies with a bend or crook in its neck.

Affected birds tend to stand in one place and move around very little unless disturbed. The head is usually drawn in toward the body, with the neck forming a distinct curve (Fig. 1). The wings may droop or hang toward the ground, and there is a distinct bulge in the region anterior to the thoracic inlet—simulating a crop.

Fig. 1. A goose affected with the chronic impaction and pressure necrosis, showing the abnormal position of the neck and the distinct bulging of the crop region, due to the impaction.

The birds make no attempt either to eat or drink after definite symptoms of the condition have developed and die within 4 to 16 hours from acute affects, or may continue in the chronic form until they starve to death. After death the head and neck of the bird tend to maintain the position assumed immediately after the impaction.

## Post-mortem Examination

Upon post-mortem examination it is not uncommon to find the soybeans just under the skin in the lower part of the neck. Pressure from the expanding beans destroys part of the wall of the esophagus in its fusiform portion and also the tissues that separate it immediately from the skin. This destruction may extend from one to three inches in both

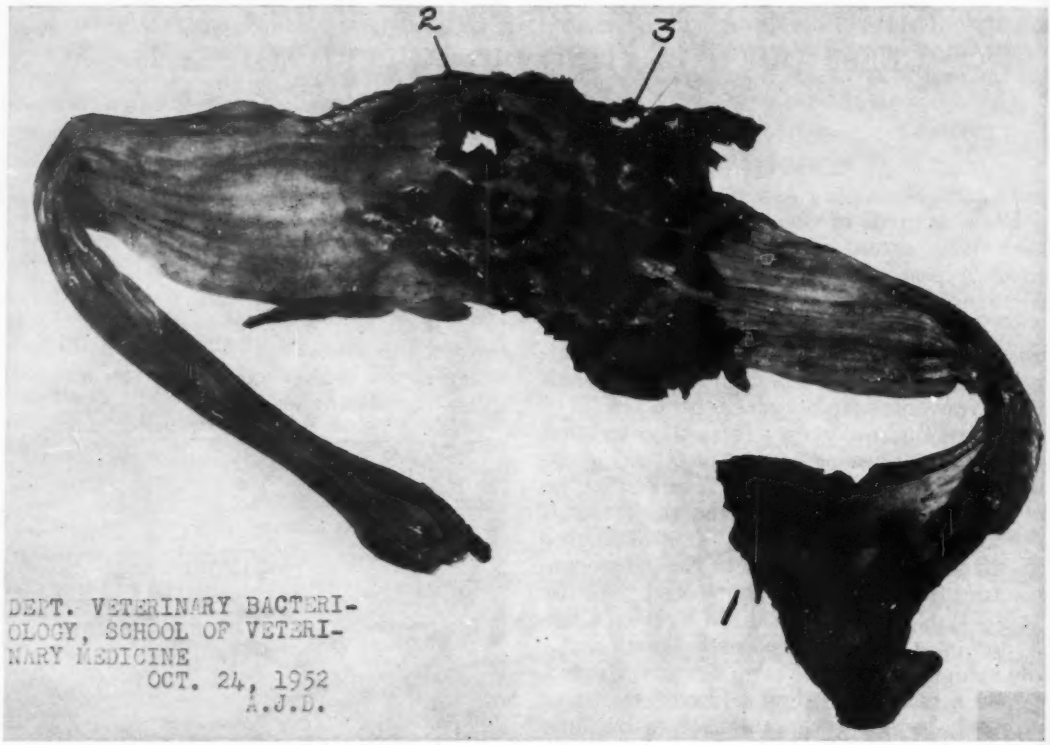



FIG. 2. The esophagus and a section of the proventriculus (1) of a chronically affected bird that died as a result of the impaction and pressure necrosis. Note that the esophagus is healthy both above and below the affected area. Note the two openings, 2 and 3, in the walls of the esophagus caused by pressure necrosis.

directions from the thoracic inlet. In less severe cases the fusiform cavity of the esophagus may be distended and contain numerous perforations varying from pinhead size to one-fourth inch in diameter (Fig. 2). It is through these openings that soybeans are forced out into the surrounding tissues, forming pockets of varying sizes filled with disintegrating soybeans. The mucosa of the esophagus and the surfaces of surrounding tissues which have been partially destroyed by pressure are black (Fig. 2).

The absence of a toxic substance was indicated by tests made by Odell (1952) as follows. Soybeans were collected from the fields where the geese were feeding and from the esophagi of acutely and chronically affected birds. These beans were ground and fed for three days to three groups of four-week-old chicks. The birds ate the ground beans but showed no symptoms of poisoning.

Benbrook (*op. cit.*) examined four dead geese in 1950 from Swan Lake Refuge and reported as follows: "One bird showed evidence of antemortem rupture of the esophagus about half way down the neck which involved the esophageal wall toward the trachea. Other esophagi showed areas of hemorrhage and also some areas of focal necrosis. There was considerable edema at the thoracic inlets of the four birds necropsied. All other structures were thought to be essentially normal although there was decomposition in three of the geese.

"It is my opinion that these geese upon arrival at the Swan Lake area had engorged themselves with dry soybeans and had then consumed water. Water causes the soybeans to swell two or three times their normal size. Pressure resulted in impaired circulation to the area. Possibly the semi-fluid fecal material resulted from the high protein and the oil content of the soybeans, especially with an absence of other feed."

During the present investigation no evi-

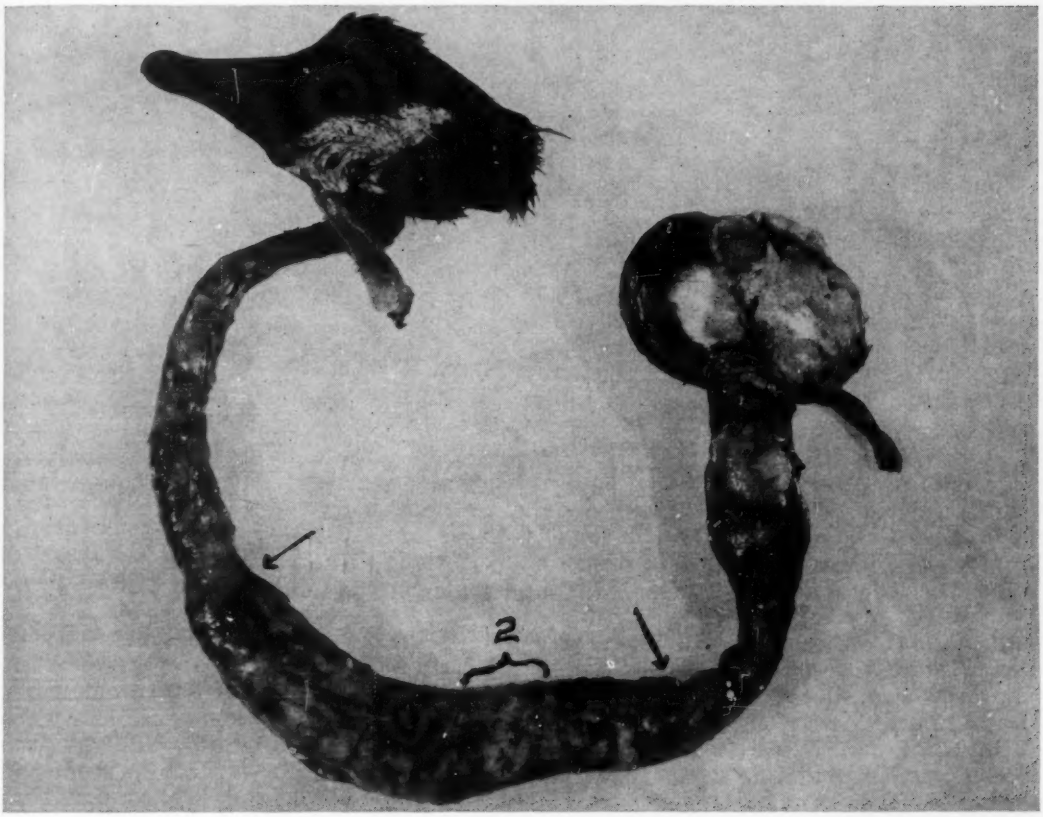



FIG. 3. The head, esophagus, proventriculus, and gizzard of an acute case. The esophagus is filled with beans from the pharynx, extending through the stomach into the gizzard. The impacted area is between the two arrows. The lighter area indicated by bracket 2 is the area immediately in the thoracic inlet.

dence was found to support the view that impaction and pressure necrosis in Canada geese are due to a secondary condition developing after paralysis of the esophagus. In the first place, paralysis of the esophagus in mammals or birds is exceedingly rare, only two cases having been reported: one in horses and one in the milk goat (Durant and Clark, 1945). In these animals the esophagus was flaccid and permanently enlarged 3 to 5 times normal size. In geese (Figs. 3 and 4) the enlargement of the esophagus occurs only in the fusiform portion adjacent to the thoracic inlet; the esophagus is normal both posterior and anterior to the affected area.

In acute cases the esophagus is not only greatly distended in the region of the thoracic inlet (Fig. 3) but contains soybeans from the pharynx to the gizzard. The slight contraction indicated by the bracket 2 is the area in the thoracic inlet, and it is here that the great pressure occurs which probably causes death of the bird. The dotted appearance of the opened esophagus, shown in Fig. 4, is caused by pressure exerted by individual beans which have destroyed the mucosa and muscularis, leaving only the serous coat. No necrosis has yet taken place. The two arrows *4* indicate points of hemorrhage in the wall of the esophagus, due to extra pressure at the thoracic inlet. The longitudinal light streak, shown by arrows *2* and *3*, is the result of pressure from the beans exerted against the trachea through the walls of the esophagus. Even in the area of greatest pressure the trachea is not collapsed. The immediate cause of death, therefore, in these acute cases is not suffocation. Perhaps the pressure cuts off the circulation to the neck and head and thus causes death.

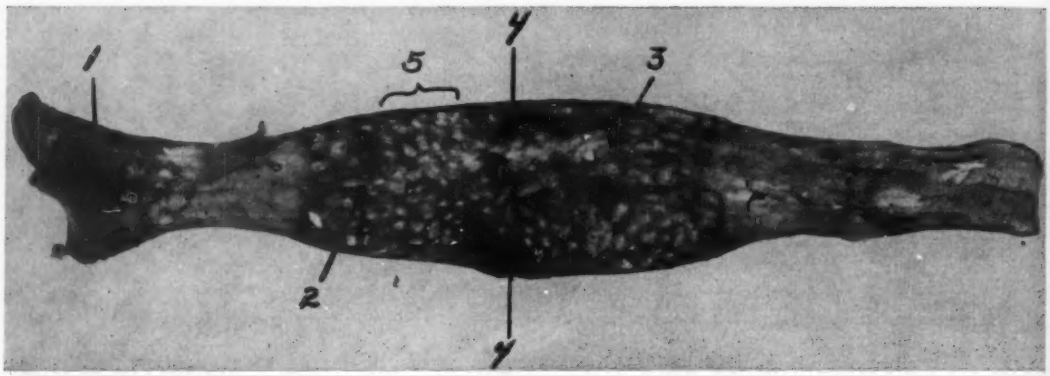



FIG. 4. Esophagus, already shown in Fig. 3, slit open and the beans removed. See text for explanation.

Hanson and Smith (1950) stated that "In the winter of 1943-44 in particular, Paul S. Smith . . . found a number of dead geese, their crops tightly packed with soybeans. Apparently these geese died after drinking water when their crops were crammed with beans. The pressure resulting when the birds imbibed water and swelled may have been the direct cause of death in such cases; the mechanism of the lethal effect is not known to us."

One bird that was examined by post-mortem evidently died from internal hemorrhage. Benbrook (1950) also reported one case. The hemorrhage resulted from extension of the pressure necrosis, which destroyed blood vessels. If birds do not die of hemorrhage, they face death from starvation because it is impossible for them to pass food or water through the destroyed area into the lower normal segment of the esophagus. In Fig. 2 it will be seen that there is no injury from impaction either in the upper cranial region of the esophagus or several inches anterior to the proventriculus (1). All of the destruction occurs at the immediate thoracic inlet where the degree of pressure is greatest from the expanding beans.

### DEGREE OF EXPANSION OF THE DRIED SOYBEANS WHEN MOISTENED

In order to determine the pressure exerted by the dried beans when moistened, some of the beans taken from the fields where the affected geese had fed were placed in a graduated cylinder with water. The beans were found to expand two and one-half times their previous volume. Such expansion would create terrific trauma not only in the fusiform portion of the esophagus where it is free to expand, but more so at the immediate thoracic inlet. This alone could cause death with the symptoms observed in either the acute form of the malady or the chronic form.

### REIMPACTION

An interesting observation was made in connection with some of the chronic cases. In several there was evidence of reimpaction with food elements entirely different than soybeans. At the point where the esophagus had been destroyed and the area of necrosis formed, there was a mass of freshly consumed greens containing lespedeza and smartweed seeds, but no soybeans. The birds were extremely emaciated and probably suffering from hunger and thirst over a comparatively long period of time. Because of the destruction of the esophagus at the thoracic inlet, the mass of green material was held in the damaged area. Perhaps if a goose does not suffer extensive destruction of the esophagus from the pressure necrosis and is able to dislodge the original impaction of beans, it may recover. Hanson and Smith (1950) also report one case that suggests reimpaction. Such cases may have led some investigators to believe that material other than soybeans or cowpeas caused the impaction and pressure necrosis.

### EXPERIMENTALLY PRODUCED CASES

The author has been able to reproduce both the acute and chronic types of impaction and pressure necrosis in Canada geese. For these experiments hand-picked dried soybeans free from dirt were used.

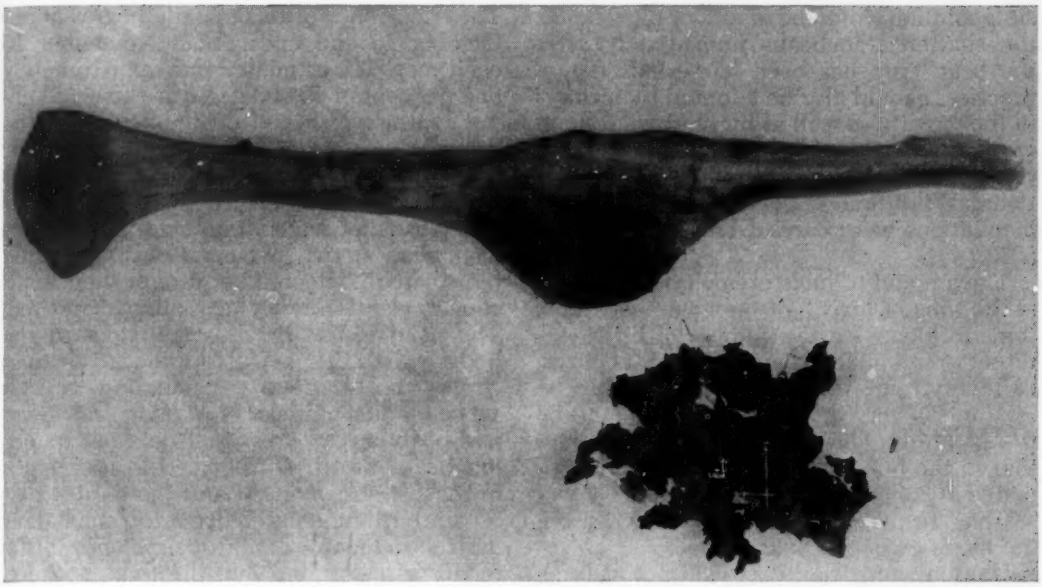


FIG. 5. A case of impaction and pressure necrosis that has destroyed a large area in one place in the esophagus without injury to the entire circumference of the esophagus. Because of the large amount of necrotic material shown, which interfered with the passage of food down the esophagus, the goose starved to death.

In order to determine the approximate number of beans necessary for typical impaction, a goose was killed and the esophagus, stomach, and gizzard removed together. A glass tube one cm. in outside diameter was then passed down the esophagus through the stomach and into the anterior portion of the gizzard. The distance was marked on the upper end of the tube at the entrance to the pharynx by means of a piece of adhesive tape. Beans were then introduced through the tube and the tube gradually raised as impaction took place from the gizzard to the pharynx. Water was then introduced and time allowed for the beans to swell to their maximum capacity. (At room temperature 36 minutes are required.) The beans were removed from the impacted organs and counted. The number was 552.

To induce impaction in live birds, complete anesthesia was found necessary. The same technique was used for introducing the beans into the live birds as was used with the excised organs, except that water was added alternately with the beans: 50 cubic centimeters of water to each 112 beans. A total of 350cc of water and 784 beans was used with a very large bird.

The artificially impacted goose died from acute impaction in approximately 16 hours. Post-mortem examination revealed the same changes as found in naturally occurring acute cases.

In one bird that was successfully impacted without anesthesia, a chronic condition developed that did not terminate fatally but resulted in pressure necrosis and perforation of the esophagus, with formation of a pocket typical of those seen in cases found in the wild.

In order to eliminate the possibility that toxic effects of the beans themselves might be involved, beans were removed from the bird (No. 273) that was artificially impacted and died of acute impaction, and were force fed to a healthy Canada goose. No symptoms developed and the goose receiving the beans remained healthy.

## RECOMMENDATIONS

If geese could be secured soon after impaction, many could be saved by lavage or by surgery before necrosis had taken place. Neither of these procedures appears practical, for sick birds are seldom found in time.

Since geese ordinarily feed only on the beans that have shattered during the harvest, and not on standing soybeans, a pos-

sible solution would be to disk or plow under the shattered soybeans immediately after the bean crop has been harvested. These practices should also be adopted by farmers in the vicinity as well as by those who share crop refuge fields. Impaction has been practically eliminated from the Swan Lake National Wildlife Refuge since these recommendations were carried out in the fall of 1953.

The amount of moisture or rain occurring at the time of arrival of the geese may have some influence on the number of birds suffering from impaction and pressure necrosis. In a very rainy season the losses should be less, and in very dry seasons they should be the greatest. This is indicated by the fact that in the fall of 1951 the losses were estimated at 300 birds, and this was a fairly wet season. In 1952, an unusually dry season, the losses exceeded 800.

Hanson and Smith (1950) conclude, "These data and field observations suggest that soybeans and cowpeas may not be ideal crops to plant for the express purpose of providing food for wintering concentrations of Canada geese."

Helm (1951) has stated that in the combine harvesting of soybeans approximately one bushel of beans is left on each acre of ground. One bushel of beans could cause the death of a very large number of geese, and Helm (1951) estimates that there were 25,800 bushels of soybeans produced in Missouri in 1951. This production will expand more and more in the Mississippi flyway, and impaction is likely to appear at other refuges. This suggests the advisability of restricting soybean production in refuge areas.

## ACKNOWLEDGMENTS

Acknowledgment is gratefully extended to Robert Russell, manager of the Swan Lake National Wildlife Refuge, and H. V. Terrill, senior biologist, Missouri Conservation Commission, both of whom assisted by furnishing affected and healthy geese for study, as well as furnishing history; also to Dr. Boyd O'Dell, who conducted the toxicity tests on the soybeans.

## SUMMARY

Impaction and pressure necrosis in Canada geese due to eating dry hulled soybeans have been observed for several years at Swan Lake National Wildlife Refuge in Missouri. The occurrence of this malady begins about October 15 and ends about November 15 each year. It is estimated that approximately one per cent of 50,000 geese are affected annually, the number of deaths depending on drought conditions occurring during the critical period. The disease is first noticed by the sudden death of geese 4 to 16 hours after drinking water following their return from feeding in soybean fields. Affected birds can be detected because of their tendency to stand in one place unless disturbed. The head is usually drawn in toward the body, with the neck forming a distinct curve. Post-mortem examination reveals soybeans just under the skin in the lower part of the neck. Pressure from the expanding beans destroys areas of the esophagus in the fusiform portion and the tissues that separate it immediately from the skin. This destruction may extend for six inches in the fusiform region and into the thoracic inlet. All of the destruction occurs at the immediate thoracic inlet where the degree of pressure is greatest from the expanding beans. These areas consist of pockets varying greatly in size and extent and filled with disintegrating beans. A few of the affected birds die from a rupture of blood vessels in the thoracic area due to the pressure of the soybeans. The illustrations depict well the gross pathology of the malady. In some cases there was definite evidence of reimpaction of entirely different food elements than the soybeans. It was possible to reproduce experimentally both the acute and chronic types of impaction and pressure necrosis. It is recommended that on refuges where soybeans are grown by share croppers, the fields should be disked or plowed immediately after harvest so that shattered soybeans will not remain available to geese.

## LITERATURE CITED

BENBROOK, S. C. 1950. Personal communication. University of Missouri.

DURANT, A. J. AND ROBERT CLARK. 1945. Paralysis of the esophagus in the milk goat. Vet. Med. Jour., 40:56-67.

HANSON, HAROLD C. AND ROBERT H. SMITH. 1950. Canada geese of the Mississippi flyway. Ill. Nat. Hist. Surv. Bull. 25:67-210.

HELM, C. A. 1951. Personal communication. University of Missouri.

O'DELL, BOYD L. 1952. Personal communication. University of Missouri.

Received for publication September 23, 1955.

# EFFECT OF A SLASH BURN ON FOREST MICE

*Lloyd Tevis, Jr.*

Department of Zoology, University of California, Davis

A discouraging aftermath of the clear-cutting of virgin forest in the Douglas-fir region of northwestern California is the enormous accumulation of waste slash. When loggers finish their work, they leave the ground cluttered and strewn with interlocking tangles of branches and tops of conifers, splintered trunks, shattered sections of bark, great piles of culled logs, and entire trees of madrone (*Arbutus menziesii Pursh*) and tanoak (*Lithocarpus densiflorus* [Hock & Arn.] Rehd.), uprooted or smashed.

During the summer this slash, which is the home of innumerable rodents, becomes dry and flammable, and constitutes a fire hazard more dangerous than any in virgin forest. By covering the ground, it makes planting of nursery stock difficult and prevents seed from reaching mineral soil.

For these reasons, slash burning is standard practice on timber lands managed by the United States Forest Service in the California Douglas-fir region. Usually the work is done after the first rains of autumn when the fuels, being somewhat damp, are less combustible. The fire is set at the upper edge of a cutover area and spreads downhill through the debris, often in spectacular fashion.

There has been considerable speculation among foresters as to the effect of fire on the abundant and prolific wild mice of the woods. These rodents are extraordinarily fond of coniferous seed, and wherever they are present in western North America, artificial seeding of logged land rarely succeeds. One theory contends that a prominent factor in the regeneration of trees on some burns is destruction of rodents by fire (Krauch, 1936: 607). In the Lake States, a recommendation was made that direct seeding should be confined to recent burns, where mice were believed to be scarce (Shirley, 1937:385). In California, Fowells and Schubert (1951:3) pointed out that burning is often suggested to reduce populations of seed-eating rodents. It is believed that resident animals perish in the blaze, and that removal of cover, whether it be brush or slash, discourages invaders. The opposite theory contends that mice survive by taking refuge in burrows and find cover and food under charred logs after the fire.

In view of the widespread interest regarding the effect of fire on forest rodents and the need for information about any method that might control them, a detailed study of a population before and after a fire was planned. The procedure was to live-trap, mark, and release the mice of a cutover prior to slash burning, and then, when the flames had died down, to blanket the area with snaptraps to capture survivors and any invaders that might come from the surrounding forest.

The cutover selected for the purpose was sixteen acres in extent, near Salyer, Trinity County, California. It was inhabited by white-footed mice (*Peromyscus maniculatus* and *P. truei*), chipmunks (*Eutamias townsendii*), wood rats (*Neotoma fuscipes*), and shrews (*Sorex trowbridgii*). The study was undertaken as part of a cooperative investigation between the Department of Zoology, University of California, Davis, and the California Forest and Range Experiment Station of the United States Forest Service.

For five consecutive nights prior to the burn, the cutover was live-trapped in order to capture all mice having homes there. A total of 397 trap nights yielded 41 *Peromyscus* (37 *P. maniculatus* and 4 *P. truei*). Many of the animals were taken more than twice and probably lived on the cutover, but others, which were caught only once, undoubtedly had their homes in the forest and only occasionally foraged on the cutover.

To ensure a blaze of sufficient intensity to put the rodent population to a severe test, burning was started before the coming of the first rains. On November 3, 1952, the slash at the upper edge of the cutover was ignited, and a hot, intense fire soon roared downhill. Log piles, where mice are most likely to have their homes, became blazing infernos; and even individual logs, with sap boiling out and spreading over their surfaces, burned so fiercely that no one could approach within twenty feet (Fig. 1). Tops of tall trees sur-

FIG. 1. Cutover during slash-fire.

rounding the cutover were tossed by columns of hot air as great mounds of slash burst into flames; and all parts of the area at one time or another were hidden under a suffocating shroud of smoke. Mice, chipmunks, shrews, and wood rats were seen to run from blazing cover, but most observations were made on rats, which are large and easily noticed. As a rule, they waited until the last moment before leaving their homes. Sometimes when they came into view they were afire from burning pitch that had fallen onto their backs. Such individuals behaved in a panic-stricken fashion. Instead of staying close to cover they streaked across open country, scattering bits of flame and setting lines of small fires in dry litter. One individual, which had been singed and was in a desperate condition, jumped frantically onto a log blazing along the base, lost its balance, and rolled off into flames.

Animals that were not afire fled in a more carefully planned, zigzagging route of short dashes from one point of cover to another. They seemed reluctant to leave their homes and familiar territory. Often, before disappearing into the virgin forest, which ordinarily is not occupied by wood rats, they made repeated efforts to turn back into the inferno. One rat, which burst out of a flaming pile, ran along the fire-line for a short distance, crouched every so often in depressions of the ground as though seeking relief from the heat, and finally, instead of entering the cool forest, returned to a pile of slash partly ringed by flames. A few moments later its escape route was closed, and it perished.

On November 6, when the burning of the cutover was completed, the skid roads and a few small islands surrounded by bare soil were the only segments not touched by fire. The remainder of the area was cleanly burned. The once massive accumulations of litter were reduced to ashes and covered the soil to a depth of two inches or more. Nearly all stumps and logs, except those completely destroyed, were charred and blackened (Fig. 2). Some continued to burn for as long as two weeks, and the smoke was dense for about two days.

FIG. 2. Same site as Fig. 1 after slash-fire.

On November 7, one day after burning was completed, 370 snaptraps (approximately 23 per acre) were distributed over the cutover in a grid pattern and generally placed near or under burned logs. This number was thought to be sufficient to ensure that no foraging mouse could survive for long without being captured. Inasmuch as the objective was to record and remove every animal that was on the cutover during the post-burn period, the traps were kept in operation for two and a half weeks and were inspected every second day.

Thirteen marked mice were recovered, a little less than one-third (32 per cent) of the original number of 41. All but 4 out of the 13 were captured at the edge of the cutover *within* the forest. In all probability, they lived in the forest and had not been on the cutover at the time of the fire.

The remaining four, which undoubtedly were residents, were taken in the central part of the cutover. Each was trapped on an island of light slash, logs, stumps, and tan-oak bushes, which, because of being surrounded and protected by bare skid roads, had escaped the flames. The smallest of these nonburned areas of ground was 20 by 20 feet; the largest, 95 by 15 feet.

Clearly, then, the fire had killed or driven out all resident mice except those few that had stayed on small areas not reached by flames. In all places where fire had been intense and slash thoroughly burned, no mouse survived.

During the first five days after the burn, the layer of ash and cinders covering the ground was a barrier to movement of small mammals. Mice could not walk on it without sinking to the depth of their bodies; and, except for one new animal trapped on the fifth day along an ash-free skid road, no invasion of the area occurred. But the nearby presence of potential invaders was indicated by the fact that fifteen mice were caught within the forest border.

Between November 12 and 14, the first major storm of the season pelted the area with approximately three inches of rain and pounded the ashes of the cutover into a firm

surface. Immediately an invasion began. Within five days the traps captured 51 mice. The ashes having been packed by rain, there was no barrier to hold back the population which had been pressing against the boundaries of the cutover.

Why do mice invade cleanly burned land where food and cover appear to have been drastically reduced? Trap-bait is not the reason, for Bole (1939:63) found that it did not influence the rate of drift. Curiosity may be an important factor as it seems to be with deer, which will wander over a burn while many of the stumps are still smoldering. But the chief reason probably lies in the fact that a vacuum has been created; nearly all resident mice have been removed from a sizeable tract of land, which therefore is wide open to settlement by newcomers. Stickel (1946:305) recorded that many more mice drift into depopulated areas than into ones that have a normal complement of residents. Although intraspecific defense of territory is poorly developed among these rodents, there seems to be a sense of ownership centered about points, such as the home site (McCabe and Blanchard, 1950:99). Recognition of this ownership by potential invaders may be instrumental in keeping them away.

At any rate, during the two and a half weeks of snap-trapping after the burn, 72 mice were taken, nearly twice the original number of 41 marked animals. Even though the residents were largely destroyed, fire did not reduce the rodent population of the cutover for more than a few days. Invaders took possession of the land. If they had not been trapped, they would have remained, for older burns in the vicinity of Salyer all have sizeable populations of mice.

These findings agree with conclusions reached elsewhere by Horn (1938:379), who observed that a breeding nucleus survived the hottest fire; Hooven (1953:8), who said that mice will immediately invade burned areas; Garman and Orr-Ewing (1949: 41), who stated that there is a rapid rise in the population within two weeks after a slash burn; Moore (1940:13), who found that mice are more numerous on burned than unburned areas; and Fowell and Schubert (1951:4), who noted that brush burning did not protect seed plantings from rodents.

In the burn that was studied at Salyer, more than two-thirds of the invading mice appeared during a five-day period beginning with the time when the ash was settled. Thereafter, the average daily rate of invasion was considerably less.

Forty-two (58 per cent) of the invaders were adults in breeding condition, and 30 (42 per cent) were gray-coated immatures which had not yet attained puberty. Out of the first 19 that invaded the cutover, only one was immature. After that, the two classes were taken in equal numbers and, by the end of the study, traps were catching twice as many immature animals as adults.

The sex ratio among the adult invaders was 200 males per 100 females, which was the same as in the population that had been marked before the fire.

Stomach analysis revealed that food of mice living in the burn consisted mainly of insects.

## SUMMARY

A 16-acre cutover in the California Douglas-fir region was live-trapped for five days prior to a slash burn and was snap-trapped for two and a half weeks thereafter. The objective was to determine if fire could be used to control seed-eating mice which hinder reforestation. Before the burn, 41 mice were captured, marked, and released. After the burn, 13 of these marked invididuals were found in the forest and 4 on small, nonburned islands in the center of the cutover. The fire had killed or driven out all resident mice except the few that had stayed on areas not reached by flames. There was no reinvasion of the cutover until rain settled the ashes. Then in two and a half weeks, 72 mice were trapped. A slash burn, therefore, does not control mice in the California Douglas-fir region.

## LITERATURE CITED

BOLE, B. P. 1939. The quadrat method of studying small mammal populations. Sci. Publ. Cleveland Mus. Nat. Hist., 5:15-77.

FOWELLS, H. A. AND G. H. SCHUBERT. 1951. Recent direct seeding trials in the pine region of California. Calif. Forest and Range Expt. Stn., Res. Note No. 78.

GARMAN, E. H. AND A. L. ORR-EWING. 1949. Direct-seeding experiments in the southern coastal region of British Columbia 1923-1949. Brit. Col. Forest Serv., Tech. Publ. T.31.

HOOVEN, E. F. 1953. Some experiments in baiting forest lands for the control of small seed eating mammals. Ore. State Bd. of For., Res. Bull. No. 8.

HORN, E. E. 1938. Some wildlife-forest relationships. Trans. 3rd N. A. Wildl. Conf., pp. 376-380.

KRAUCH, H. 1936. Some factors influencing Douglas fir reproduction in the southwest. Jour. For., 34:601-608.

MCCABE, T. T. AND B. D. BLANCHARD. 1950. Three species of Peromyscus. Santa Barbara, Rood Associates. v + 136 pp.

MOORE, A. W. 1940. Wild animal damage to seed and seedlings on cutover Douglas fir lands of Oregon and Washington. U.S. Dept. Agric., Tech. Bull. No. 706.

SHIRLEY, H. L. 1937. Direct seeding in the Lake States. Jour. For., 35:379-387.

STICKEL, L. F. 1946. The source of animals moving into a depopulated area. Jour. Mamm., 27: 301-307.

Received for publication July 15, 1955.

# PRODUCTIVITY OF CANADA GEESE IN THE FLATHEAD VALLEY, MONTANA

*Mary Barraclough Geis*

Montana Cooperative Wildlife Research Unit, Missoula, Montana

Published studies of productivity of the Great Basin Canada goose (*Branta canadensis moffiti*) include those made in Utah (Williams and Marshall, 1937, 1938), in Wyoming (Craighead and Craighead, 1949), and in California (Dow, 1943; Naylor, 1953; Miller and Collins, 1953; Naylor and Hunt, 1954). Although these studies have made it possible for waterfowl managers to estimate productivity of goose populations with some confidence, they have been incomplete in one or more respects. In most cases the studies have been based on samples of the breeding population in areas where the nonbreeding element was not definitely known, thus making it impossible to estimate the productivity of the total population with certainty. Because of the difficulty of determining gosling mortality, productivity has been estimated from the number of young hatched rather than from the number of young reaching harvestable age. Also, the extent of renesting and its compensatory effect has not been considered.

This paper represents the first phase of an extended study being carried on by the Montana Cooperative Wildlife Research Unit[1] in close cooperation with the Pittman-Robertson Division of the Montana State Fish and Game Department. The author is indebted to Dr. John J. Craighead, unit leader, for his guidance, advice, and assistance in all phases of the study. She is also grateful to Gerald Salinas, waterfowl biologist, and to other Fish and Game Department personnel and student assistants for help in the field.

In recent years the growing human population of western Montana, combined with a mounting interest in goose hunting, has greatly increased pressures on the Flathead Valley goose population. Band returns during 1953 and 1954 indicate that in some years local geese furnish over 50 per cent of the annual hunter kill of several hundred geese in the area. It is becoming evident that future goose hunting in the Flathead Valley may depend on how well management is able to maintain and increase the productivity of the local population.

In the present study, the breeding population of Canada geese in the Flathead Valley, Montana, was studied as a unit. This was possible because the population is relatively small and stable during the breeding season and because the breeding areas are accessible and have clearly defined geographic limits. Under these conditions population composition could be assessed, nesting behavior observed, brood movements followed, and gosling survival determined.

## THE STUDY AREA

The study area included Flathead Lake, the Flathead River for a distance of about 50 miles south and west of the lake, and the lower Flathead Valley south of Flathead Lake. The Flathead River north of Flathead Lake was not included in the study because

[1] The U.S. Fish and Wildlife Service, the Montana State University, the Montana State Fish and Game Department, and the Wildlife Management Institute cooperating.

of the limits of time and personnel, but a few pairs of geese are known to nest in that area.

Flathead Lake is approximately 30 miles long and averages about 8 miles in width. A number of wooded islands in the south and west portions of the lake provide goose nesting sites, and shallow bays and agricultural lands along parts of the north, west, and south shores are used by geese as resting, feeding, and brood-rearing areas. A maximum fluctuation in water level of 10 feet occurs between high water in midsummer and low water during winter and early spring. In years of low water, extensive mud flats are exposed in shallow areas of the lake during winter and spring. Water levels are controlled at Kerr Dam, a substation of the Montana Power Company, which is located on the Flathead River five miles south of its outlet from the lake.

The lower Flathead Valley is a broad glaciated valley bordered on the east by the precipitous Mission Mountains and on the west by the Flathead River and a series of foothills. The valley is intensively farmed and contains a number of irrigation reservoirs. The largest of these, Ninepipe and Pablo reservoirs, are maintained as migratory bird refuges by the U.S. Fish and Wildlife Service. Pablo Refuge is an important feeding and resting area for geese during summer and fall but is not used for nesting. Ninepipe Refuge supports a small nesting population, and is also used as a feeding and resting area.

The Flathead River south of Flathead Lake is bordered along part of its course by rock cliffs and clay banks. In other areas the river broadens, forming numerous islands and channels. Oxbow sloughs and marshes adjoin the river in some areas. Much of the bottomland along the river is utilized for agriculture. Heavy water releases at Kerr Dam in May and June usually result in flooding of the islands and bottomland meadows.

The economy of the Flathead Valley is based largely on agriculture and on the tourist and recreation industries. The geese are an important asset to the recreation interests, attracting hunters to the area each fall. Although the geese are often blamed for damaging agricultural crops, no serious depredation problem exists.

## STUDY METHODS

Census of the geese during the breeding season and determination of population composition were made by aerial and ground counts in conjunction with the nesting studies.

Ground counts were made on the lake and reservoirs from a boat and from the nesting islands. Frequent counts were also made on the feeding and resting areas on the mainland. The entire stretch of river was run by boat three times during the 1953 breeding season and four times during the 1954 breeding season.

Aerial counts were made three times during the 1953 breeding season and once during the 1954 breeding season. The aerial counts were useful in locating flocks of nonbreeding birds, in checking ground counts of these flocks, and obtaining an over-all picture of the distribution of the geese. Aerial counts alone did not give an accurate picture of the number of breeding geese in the study area. Laying and incubating geese often could not be located from the air because of the dense cover on most of the nesting islands, and all counts of paired birds exhibiting territorial defense had to be interpreted in light of known numbers of nests. Many young nonbreeding pairs frequented the nesting areas during the breeding season, and some of these exhibited territorial behavior but did not nest. Similar evidence of pairing and territorial behavior by nonbreeding geese was noted in California by Naylor (1953) and by Naylor and Hunt (1954), and in Wyoming by Patterson and Ballou (1953).

During the nesting survey all islands in the lake, river, and reservoirs were visited periodically and searched thoroughly for nests. Areas on the mainland where pairs were observed were also searched. Nests were located at all phases of the nesting cycle but were most often found during incubation, when females flushed at close range. Intervals between visits averaged two to three weeks, but in 1953 the Bird Islands in Flathead Lake were visited weekly. Visits to nests were avoided in bad weather, and time on the islands was kept at a minimum in order to disturb the geese as little as possible. Nests were marked with numbered tags and their locations plotted on maps. Field data were recorded on maps and later transferred to individual nest-history forms. At the end of the season, data from all nests were tabulated and summarized.

In order to determine the relationship of

the nesting islands to the critical brood-rearing areas on Flathead Lake, some eggs on each island were injected with vegetable dyes a few days before hatching (Evans, 1951). Goslings so marked retained the color until the natal down was replaced by juvenile plumage at an age of five to six weeks. Movements of marked broods were easily followed. Brood counts were made periodically on the lake and reservoirs during the brood-rearing season, which extended from April 15 to July 15. Counts on the river required considerable time and preparation and were made only two or three times during the brood season. Aerial brood counts proved to be of little value in counting goslings. Gosling mortality was determined by comparing total number of young hatched in the area with the total number of young reaching flying age in midsummer. The productivity of the population was estimated on the basis of the number of young that attained flight. Since mortality taking place between the time flight was attained in July and the opening of the hunting season in October was negligible, young that attained flight were considered harvestable young.

## NESTING DATES

Nesting activity began on the islands in Flathead Lake in February, when many pairs were defending territory and scooping out nesting hollows. The first eggs were laid about March 15, and the peak of laying occurred during late March and early April. The first goslings hatched about April 15, and the peak of the hatch was in late April and early May. All nesting had ceased by May 25. Nesting and hatching dates in western Montana (elev. about 3,000 ft.) were almost identical to those reported in northeastern California (elev. about 4,000 ft.) by Dow (1943) and Naylor (1953). Nesting dates reported by Craighead and Craighead (1949) in Wyoming at an elevation of about 6,500 feet were two weeks later than those found in California and in the Flathead Valley.

## POPULATION COMPOSITION

Data on population composition are presented in Table 1. The number of breeding pairs was determined by subtracting the number of nests thought to be renests from the total number of nests located in the area. The concentration of nests on islands and repeated visits made it possible to locate practically all nests. Where nests were inaccessible, as were those in osprey (*Pandion haliaetus*) nests and in some swamp areas, their presence was ascertained through repeated observations of the behavior of a nesting pair. Data on renests were not conclusive, as individual geese could not be recognized. Nests were designated renests when they appeared in an area following failure of a nest in the same territory.

The number of nonbreeding geese was determined by subtracting the number of breeding geese from the total population in the area. Census figures for the total population remained approximately constant throughout the breeding season and are be-

TABLE 1. — NUMBER OF NESTS AND COMPOSITION OF THE BREEDING POPULATION

| | Flathead Lake | | Flathead River | | Ninepipe Refuge | | Totals for Area | |
|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 |
| Total number of nests located | 184 | 173 | 34 | 70 | 7 | 11 | 225 | 254 |
| Probable number of renests | 19 | 24 | 5 | 10 | 1 | 4 | 25 | 38 |
| Number of nesting pairs | 165 | 149 | 29 | 60 | 6 | 7 | 200 | 216 |
| Number of breeding geese | 330 | 298 | 58 | 120 | 12 | 14 | 400 | 432 |
| Number of nonbreeding geese | 190 | 490 | 162 | 125 | 48 | 30 | 400 | 645 |
| Total number of geese | 520 | 788 | 220 | 245 | 60 | 44 | 800 | 1,077 |

TABLE 2. — DISTRIBUTION OF NESTS BY HABITAT

| Area | Islands | Osprey or Heron Nests | Cliffs or Peninsulas | Muskrat Houses in Marshes | Total |
|---|---|---|---|---|---|
| Flathead Lake | 338 | 12 | 3 | 4 | 357 |
| Flathead River | 80 | 12 | 5 | 7 | 104 |
| Ninepipe Refuge | 14 | 0 | 4 | 0 | 18 |
| Totals | 432 | 24 | 12 | 11 | 479 |

lieved to be an accurate representation of the number of geese in the area.

The significance of the ratios of breeding to nonbreeding birds cannot be judged at this time, since the extent of movements of young geese into and out of the area before the breeding season has not been determined. It is possible that the higher ratio of nonbreeding geese in 1954 reflects the high productivity in the 1953 breeding season and a resulting greater number of yearlings in the area in 1954.

A slight increase in the breeding population of the entire study area in 1954 represents a small decrease in the number of breeding pairs on Flathead Lake but a 100 per cent increase in the nesting population on the Flathead River. The sharp increase in nesting on the river in 1954 has not been explained.

## LOCATION OF NESTS

The distribution by habitat of the 479 nests located in the two years of the study is shown in Table 2. Over 90 per cent of the nests were on islands, a habitat preference of nesting geese that has been found by other workers. Nests not on islands were on isolated peninsulas, in old heron or osprey nests in trees, on cliffs along the river, or on muskrat (*Ondatra zibethica*) houses in marshes.

Small islands supported a much greater nesting density than did larger islands. The inverse relationship between size of islands in Flathead Lake and nesting density on those islands is shown in Table 3. No data on acreage of the islands in the river were available, but the relationship was also evident in that area.

TABLE 3. — NESTING DENSITY AS RELATED TO SIZE OF ISLANDS IN FLATHEAD LAKE

| Acreage Class of Island | No. of Islands | Total Acreage | Total Nests (2-yr. Avg.) | Avg. Nests per Acre |
|---|---|---|---|---|
| 0.5 to 2 acres | 5 | 5.22 | 35 | 6.70 |
| 2 to 5.5 acres | 4 | 18.12 | 50 | 2.76 |
| 20 to 30 acres | 4 | 105.80 | 54 | 0.51 |

The islands of Flathead Lake are largely wooded with vegetation characteristics of the Douglas fir-ponderosa pine zone in western Montana. The elevation of some of the islands reaches 30 to 50 feet above lake level (about 3,000 ft.), and all have rocky shore lines and numerous ledges and bluffs. A variety of nesting cover was used by the geese nesting on these islands. The majority of nests were on open sites with some view of surrounding territory and easy access to water, but a surprising number of nests on the lake (approximately 25 per cent) were situated in woods or under heavy brush cover, often 100 to 300 feet from water.

Islands in the Flathead River are low and mostly covered with a shrubby river-bottom vegetation. Nests on these islands were within a few feet of the water and typically were situated on open sites under juniper (*Juniperus* sp.) red osier (*Cornus stolonifera*), or willow (*Salix* sp.). On Ninepipe Refuge nests were on weed-covered islands or on exposed gravel bars with little or no vegetation.

A large number of nest sites are reused in successive years. On Flathead Lake 48 of the nests in 1954 were on the exact sites used in 1953. An additional 30 nests were within 25 feet of sites used in 1953. Thus 78, or 45 per cent, of the 1954 nests on the lake were on the same site or within 25 feet of the same sites used in 1953.

## CLUTCH SIZE

Data on frequency of clutch size and mean clutch size in the two years of the study are presented in Table 4. Only data from nests in which incubation had begun and clutches were known to be complete were used in determining mean clutch size.

TABLE 4. – CLUTCH SIZE AND FREQUENCY

| Year . . . . . | 1953 | 1954 |
|---|---|---|
| Clutch Size | Clutch Frequency | |
| 2 | 2 | 0 |
| 3 | 11 | 16 |
| 4 | 21 | 39 |
| 5 | 53 | 61 |
| 6 | 47 | 50 |
| 7 | 18 | 19 |
| 8 | 12 | 3 |
| 9 | 3 | 1 |
| 10 | 2 | 0 |
| Total no. nests with complete clutch data | 169 | 189 |
| Total no. eggs in these nests | 937 | 975 |
| Mean clutch per nest | 5.55 | 5.15 |

TABLE 5. – HATCHING SUCCESS

| Year . . . . . | 1953 | 1954 |
|---|---|---|
| Hatch Size | Hatch Frequency | |
| 0 (unsuccessful) | 54 | 109 |
| 1 (successful) | 0 | 2 |
| 2 | 6 | 6 |
| 3 | 9 | 16 |
| 4 | 21 | 18 |
| 5 | 38 | 27 |
| 6 | 26 | 25 |
| 7 | 12 | 7 |
| 8 | 5 | 0 |
| 9 | 1 | 0 |
| 10 | 1 | 0 |
| Total number of nests with hatch data | 173 | 210 |
| Total number of young from these nests | 612 | 468 |
| Mean hatch per nest—all nests with data | 3.53 | 2.22 |
| Mean hatch per nest—successful nests only | 5.14 | 4.64 |
| Number of unhatched eggs in successful nests | 66 | 75 |
| Total number eggs laid in successful nests | 678 | 543 |
| Per cent of eggs hatched in successful nests | 90 | 86 |

### HATCHING SUCCESS

Mean hatch per nest was calculated using data from all nests, both successful and unsuccessful, and again using data from successful nests only (Table 5). The per cent of eggs hatched in successful nests was determined by dividing the number of young hatched in successful nests by the number of eggs laid in these nests. Successful nests are defined as those nests in which at least one egg hatched.

Table 5 indicates that over 85 per cent of the eggs hatched in successful nests in both years. Of the 141 unhatched eggs tabulated in Table 5 in two years, 56 per cent were infertile or had embryos that died at an early stage of development; 18 per cent contained recognizable dead embryos at various stages of development; 14 per cent were destroyed by crows (*Corvus brachyrhynchos*) or other predators; and 11 per cent disappeared and were probably destroyed by predators.

### NESTING SUCCESS

Nesting success, expressed as the percentage of known-fate nests that hatched at least one egg and as the percentage of breeding pairs that brought off at least one gosling, is shown in Table 6. In both years the fate of 88 per cent of the nests was known. The percentage of successful known-fate nests was projected in order to calculate the approximate total number of successful nests and the per cent of successful breeding pairs. When renesting was thus considered and nesting success calculated as the per cent of breeding pairs successful, nesting success was about nine per cent higher in both years than when nesting success was calculated as the per cent of nests successful. The data indicated that between 30 and 40 per cent of unsuccessful pairs made renesting attempts.

### TOTAL PRODUCTION OF EGGS AND YOUNG

The approximate total number of eggs laid and young hatched in the study area was determined by projecting data on clutch and hatch obtained from about 80 per cent of the nests (Tables 4 and 5) to the remaining nests from which complete data on clutch and hatch were not available.

The mean clutch size in both years was determined on the basis of data from about 75 per cent of the nests (Table 4). An additional 5 per cent of the nests furnished data on the number of eggs laid but were not used in determining mean clutch size because they were abandoned or destroyed before it was certain that clutches were completed.

Data on hatch were obtained from 77 per cent of the nests in 1953 and 83 per cent of the nests in 1954 (Table 5). In projecting data on hatch, the mean hatch in all nests

TABLE 6. — NESTING SUCCESS

| | Flathead Lake | | Flathead River | | Ninepipe Refuge | | Totals for Area | |
|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 |
| Total number of nests located | 184 | 173 | 34 | 70 | 7 | 11 | 225 | 254 |
| Number of known-fate nests | 161 | 162 | 31 | 51 | 7 | 11 | 199 | 224 |
| Number successful known-fate nests | 115 | 82 | 24 | 27 | 6 | 6 | 145 | 115 |
| Per cent successful known-fate nests | 71 | 51 | 77 | 53 | 86 | 55 | 73 | 51 |
| Calculated total successful nests | 132 | 88 | 26 | 37 | 6 | 6 | 164 | 130 |
| Number of nesting pairs | 165 | 149 | 29 | 60 | 6 | 7 | 200 | 216 |
| Calculated per cent pairs successful | 80 | 59 | 90 | 62 | 100 | 86 | 82 | 60 |

TABLE 7. — PRODUCTION OF EGGS AND YOUNG

| | Flathead Lake | | Flathead River | | Ninepipe Refuge | | Totals for Area | |
|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 |
| EGGS | | | | | | | | |
| Number nests with data on clutch[1] | 157 | 147 | 15 | 57 | 7 | 7 | 179 | 211 |
| Total number eggs in these nests | 831 | 680 | 98 | 309 | 41 | 35 | 970 | 1,024 |
| Number nests with no data on clutch | 27 | 26 | 19 | 13 | 0 | 4 | 46 | 43 |
| Calculated number of eggs these nests[2] | 150 | 134 | 105 | 67 | 0 | 21 | 255 | 222 |
| Calculated total number of eggs | 981 | 814 | 203 | 406 | 41 | 56 | 1,225 | 1,246 |
| YOUNG | | | | | | | | |
| Number nests with data on hatch | 151 | 156 | 15 | 44 | 7 | 10 | 173 | 210 |
| Total number young from these nests | 533 | 337 | 46 | 104 | 33 | 27 | 612 | 468 |
| Number nests with no data on hatch | 33 | 17 | 19 | 26 | 0 | 1 | 52 | 44 |
| Calculated number young from these nests[3] | 116 | 38 | 68 | 82 | 0 | 6 | 184 | 126 |
| Calculated total number of young hatched | 649 | 375 | 114 | 186 | 33 | 33 | 796 | 594 |

[1] Includes data from incomplete clutches.
[2] Calculated on basis of mean clutch of 5.55 in 1953, 5.15 in 1954.
[3] Calculated from mean hatch in successful nests (5.14 in 1953, 4.64 in 1954) in some cases, from mean hatch in all nests (3.53 in 1953, 2.22 in 1954) in other cases.

was used in cases where the fate of the nest was not known, and the mean hatch in successful nests only was used in cases where the nest was known to be successful but exact data on hatch were not obtained. Examples of the latter case are osprey nests where bits

of hatched shell were found on the ground under the nest but no egg count was possible.

### RELATION OF CLUTCH SIZE TO COVER AND NESTING SUCCESS

In the course of the investigation it was noted that nests which were hidden in dense cover often had larger than average clutches. It was also noted that the nests with large clutches were not often deserted or destroyed. Data on clutch size, use of nesting cover, and nesting success of geese nesting on Flathead Lake in two years of study were tabulated with the results shown in Table 8.

TABLE 8. — RELATION OF CLUTCH SIZE TO NESTING SUCCESS AND USE OF COVER

| Clutch Size | Number of Nests | Nests in Dense Cover | | Successful Nests | |
|---|---|---|---|---|---|
| | | Number | Per cent | Number | Per cent |
| 4 or less | 82 | 16 | 20 | 32 | 39 |
| 5 | 88 | 23 | 26 | 65 | 74 |
| 6 | 76 | 25 | 33 | 58 | 76 |
| 7 or more | 31 | 13 | 42 | 27 | 87 |
| All nests | 277 | 77 | 28 | 182 | 66 |

The apparent relationship between clutch size, use of cover, and nesting success could be explained on the basis of an age factor if larger clutch size is related to increased age, a possibility that has been suggested by game breeders and others experienced in raising geese (Hanson and Smith, 1950). The lower success of nests with small clutches is not due to desertion of incompleted clutches, as only clutches that had been incubated for three or more days were included in the data of Table 8. Nests were classified as being in dense cover if the goose had no view of water from the nest or if she could not fly directly from the nest because of intervening brush or trees.

### CAUSES OF NESTING FAILURE

The major causes of nesting failure in known-fate nests are indicated in Table 9. The figures show that destruction was the most important cause of nesting failure. However, desertion that occurred before destruction took place could not always be detected, and it is probable that desertion as a primary cause of nesting failure was more important than the figures suggest.

Over 90 per cent of the destruction of nests was by crows or ravens (*Corvus corax*). A few cases of mink (*Mustela vison*) predation were observed, and a very few cases of predation by badger (*Taxidea taxus*), skunk (*Mephitis mephitis*), and dog were suspected. Magpies (*Pica pica*) nested in the vicinity of some of the goose nests, but no predation by magpies was found. Predators were identified through the presence of the predator in the vicinity of destroyed nests and by the sign found at the nest (Reardon, 1951; Craighead and Craighead, 1949). In a few instances predation by crows was traced when the birds ate goose eggs injected with dye for brood studies, and red or green droppings were observed under roosting trees.

TABLE 9. — HISTORY OF KNOWN-FATE NESTS

| Fate | 1953 | | 1954 | |
|---|---|---|---|---|
| | No. of Nests | Per cent | No. of Nests | Per cent |
| Hatched | 145 | 73 | 115 | 51 |
| Destroyed | 32 | 16 | 62 | 28 |
| Deserted | 22 | 11 | 37 | 17 |
| Flooded | 0 | 0 | 10 | 4 |
| Totals | 199 | 100 | 224 | 100 |

Causes of desertion could not always be established, but in most cases the characteristics of individual geese seemed to be an important factor. Some geese were more tolerant of disturbance than were others. If it is true that first-year nesters lay fewer eggs than do older geese, then the very low nesting success among geese that laid clutches of four eggs or less (Table 8) might indicate that young geese are more likely to desert or do not hide or defend their nests as well as do older birds.

Naylor (1953) and Miller and Collins (1953) attributed a high rate of desertion on refuge areas in northeastern California to intraspecific strife due to crowding. Competition for nest sites such as that described by these authors was not observed in the Flathead Valley, and there was no evidence that crowding was an important cause of desertion. Naylor (*op. cit.*) cites one instance where an island of one-half acre supported a total of 31 nests, a nesting density of about 62 nests per acre. The greatest nesting density found on islands of comparable size in Flathead Lake was 8 to 12 nests or 15 to 25 nests per acre.

Near-zero temperatures occurring at the height of the laying period (Mar. 30-April 3) in 1954 resulted in chilling of many eggs before incubation had begun and probably

caused much of the desertion and poor hatching success in that year.

Disturbance by the investigators was not believed to be an important cause of desertion, since visits were short and the geese were not kept away from the nest long enough to cause chilling of the eggs. Human disturbance over extended periods apparently did increase the desertion rate. This was indicated on two islands in the lake where people were living during part of one nesting season. In one case six out of eight nests were deserted, and in the other six out of nine nests were deserted. In years of no human disturbance, nesting success was above average on these two islands.

Flooding caused some loss of late nests on the river in 1954, when 10 nests were destroyed in this way before hatching. Flooding occurs on the river when heavy releases of water from Flathead Lake are made at Kerr Dam. The majority of the nests hatch before flooding occurs, but if water releases were earlier or nesting later, flooding might cause much greater losses in this area. Some nests on the lake were located below the high-water level, but these hatched before the lake level rose.

### BROOD MOVEMENTS

Observations of 21 color-marked broods on the lake indicated that broods left the nesting islands, where no food was available, within 48 hours after hatching. Most broods traveled a distance of six to ten miles over open water or over water and land to reach areas of the lake where there was a plentiful supply of aquatic vegetation or pasture grass. Many broods traveling from the Bird Islands to Polson Bay journeyed overland across Finley Point for a distance of nearly a mile. There were seven brood-rearing areas on the lake, each consisting of from one to five miles of shore line in a shallow marshy area or an agricultural area. Once broods were established in a rearing area they rarely moved to other brood grounds.

No color marking was attempted on the river, and movements of broods in that area were not definitely determined. It appeared that broods moved downstream from nesting areas and congregated where pastures were adjacent to the river.

### GOSLING COUNTS

Frequent counts of young and adults on the rearing grounds were used in determining the number of geese using the brood-rearing areas, the average brood size, the extent of brood grouping, and gosling mortality (Table 10).

Complete counts were not always obtained in a brood area and were especially difficult to make early in the brood period when broods were scattered, and goslings were small and could be easily concealed. Early brood counts were also hindered by the low lake level, which often made it necessary for broods to cross 100 to 500 yards of exposed flats to get from feeding areas to open water. Under these conditions goslings often took cover in cattails (*Typha* sp.) or brush when disturbed. The best counts were made on calm days late in the brood season when the lake was high and goslings took to open water when alarmed.

Table 10 shows the number of counts made in the major rearing areas during each season and the best total count obtained in each area. The "best total count" is the max-

TABLE 10. — BROOD COUNTS AND AVERAGE BROOD SIZE

| Area | Number of Brood Counts | | Best Total Count | | Avg. Brood at Hatching | | Avg. Brood at End of Season | |
|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 |
| Flathead Lake | | | | | | | | |
| North end | 4 | 4 | 160 | 90 | — | — | 6.40 | 4.95 |
| Big Arm Bay | 7 | 4 | 80 | 46 | — | — | 6.67 | 4.64 |
| West Polson Bay | 11 | 6 | 103 | 83 | — | — | 5.72 | 4.18 |
| East Polson Bay | 21 | 6 | 152 | 74 | — | — | 8.90 | 5.40 |
| Entire lake | — | — | 495 | 293 | 5.08 | 4.44 | 6.88 | 4.54 |
| Flathead River | 2 | 3 | 106 | 170 | 5.75 | 5.20 | 5.30 | 5.30 |
| Ninepipe Refuge | 5 | 4 | 33 | 33 | 5.50 | 5.50 | 5.50 | 5.50 |
| Entire study area | — | — | 634 | 496 | 5.14 | 4.64 | 6.46 | 4.81 |

imum count made under good conditions near the end of the brood period, and in most cases is supported by two or more counts.

To check on the reliability of the best total count in an area where all broods were seldom seen, counts were made three or four times weekly in the East Polson Bay area during the latter part of the 1953 brood season. The frequency of observation of two colored broods using the area was used as an index to the percentage of all goslings in the area that were being seen and recorded during an average count.

No. of times marked broods could have been seen = 2 broods × 16 counts = 32 times

Times marked broods were seen = 18 times

$$\text{Frequency of observation} = \frac{18}{32} = 0.56$$

Avg. no. of young seen in each of 16 counts = 79

Probable total no. of young in area = $\frac{79}{0.56} = 142$

The best total count of 152 was obtained twice and corresponds closely to the figure (142) obtained by using the marked brood index explained above. The best total count was used as a measure of the number of young that survived until the end of the brood season.

### Brood Grouping

There was a marked tendency for broods to regroup and combine, especially on the more crowded rearing areas. In Table 10 the mean brood size at hatching (mean hatch in successful nests) is compared with mean brood size on the major rearing areas near the end of the brood season (June 15-30). Grouping was most pronounced on the East Polson Bay rearing area where broods were most crowded. In 1953 one "brood" of 40 goslings was observed throughout the season in that area. A brood of four color-marked goslings became part of a brood of twelve soon after hatching, later was seen alone, and ended the season as part of a brood of eight. Grouping on the lake was much less in 1954 when there were 40 per cent fewer goslings using the rearing areas. Brood grouping was not common on the river where broods were scattered along 50 miles of river or on Ninepipe Refuge where there were only six broods.

A similar increase in mean brood size during the brood-rearing season was noted in Utah by Williams and Marshall (1938) and in California by Naylor (1953) and Miller and Collins (1953). Hanson and Smith (1950) suggest that the observed tendency for family groups of geese in the Mississippi Flyway to remain intact (Elder and Elder, 1949) may be due to widely scattered nesting on their subarctic breeding grounds.

### Gosling Mortality

Because brood grouping masked any regression in brood size, decline in average brood size could not be used as an index to gosling mortality. Estimates of gosling mortality presented in Table 11 are based on comparison of the number of young at time of hatching with the number of young in the area at the end of the brood season (June 15-30).

Gosling mortality reached significant proportions only on Flathead Lake, and most of the mortality on the lake apparently occurred in the Polson Bay area. If conclusions about movements of broods from the nesting islands were correct, mortality in the western

Table 11. — Gosling Mortality in Study Area

| | Flathead Lake | | Flathead River | | Ninepipe Refuge | | Total for Area | |
|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 | 1953 | 1954 |
| No. young hatched | 648 | 375 | 115 | 186 | 33 | 33 | 796 | 594 |
| No. young at end of brood period | 495 | 293 | 106 | 170 | 33 | 33 | 634 | 496 |
| No. young lost | 153 | 82 | 9 | 16 | 0 | 0 | 162 | 98 |
| Per cent lost | 24 | 22 | 8 | 9 | 0 | 0 | 20 | 16 |

and northern portions of the lake was about 7.5 per cent, while mortality in Polson Bay was about 33 per cent.

The high mortality in the Polson Bay area is thought to be partly due to the fact that many geese lead 2- to 3-day-old broods over Finley Point in traveling from the Bird Islands to East Polson Bay. Residents in that area have found young stranded in cattle guards, deserted on roads, and killed by dogs or cats. The low water levels early in the brood period probably increased mortality in the East Polson Bay area by making young vulnerable to predators. Mink were abundant in the area, as evidenced by attacks on domestic poultry on nearby farms and by numerous tracks on the mud flats. Dogs, and occasionally coyotes (*Canis latrans*), also roamed the exposed flats in this brood-rearing area.

There was little mortality on the areas of the lake where open water was close at hand and where there was little cover for predators. Human residences and activity in the West Polson Bay and Big Arm Bay areas had no adverse effect on gosling survival. The relatively low mortality on the Flathead River was attributed to the protection afforded by numerous islands and channels, deep water, and swift currents.

### ACTUAL AND POTENTIAL PRODUCTIVITY

From the viewpoint of management, productivity of the population must be evaluated in terms of the number of harvestable geese produced each year. In the present study the number of young geese reaching flying age in July was used as a measure of annual productivity of the Flathead Valley goose population. Productivity data are summarized in Table 12.

In both years of the study the actual productivity of the population was considerably lower than the potential productivity. If each of the 200 nesting pairs in 1953 had successfully hatched an average clutch of 5.5 eggs and raised them to the flying age, a total of 1,100 young would have been produced. Actual productivity was 634 young or about 57 per cent of the potential. Of the 466 potential goslings lost, about 304 were lost in the nest through destruction or desertion of eggs, and about 162 were lost between hatching and the attainment of flight. Each breeding pair produced an average of 3.16 harvestable young in 1953.

TABLE 12. – SUMMARY OF PRODUCTIVITY DATA, FLATHEAD VALLEY

| | 1953 | 1954 |
|---|---|---|
| Total number of geese | 800 | 1,075 |
| Number of nonbreeding geese | 400 | 643 |
| Number of breeding geese | 400 | 432 |
| Number of nesting pairs | 200 | 216 |
| Number of nests | 225 | 254 |
| Number of renests | 25 | 38 |
| Per cent successful | 73 | 51 |
| Per cent pairs successful | 82 | 60 |
| Mean clutch size | 5.55 | 5.15 |
| Mean hatch per nest | 3.53 | 2.22 |
| Total number eggs laid | 1,225 | 1,276 |
| Total number young hatched | 796 | 594 |
| Number goslings lost | 162 | 98 |
| Per cent goslings lost | 20 | 16 |
| Number young reaching harvestable age | 634 | 496 |
| Young per breeding pair reaching harvestable age | 3.16 | 2.32 |

In 1954, 216 nesting pairs produced about 496 young at the end of the breeding season, or 42 per cent of a potential production of 1,190 young. Of the 694 potential young lost, 596 were lost before hatching and 98 after hatching. The higher mortality in the nest in 1954 was partially compensated for by increased renesting and lower gosling mortality. In 1954 each nesting pair produced an average of 2.32 young that reached harvestable age.

The most important factors limiting productivity appeared to be nesting failures due to desertion, predation, and predation following desertion. Adverse weather conditions were also important. Flooding was of little importance but could cause more destruction in other years. Lack of preferred nesting habitat may limit the number of breeding pairs using certain areas. Gosling mortality was an important factor limiting productivity only in a few areas on the lake where overland movements of broods and low water levels made young vulnerable to predators.

The effectiveness of management in controlling some of these factors so as to increase the annual productivity of the population will be tested in future studies.

## SUMMARY

A study of productivity of a local population of Canada geese was made in 1953 and 1954 in the Flathead Valley of Montana. Population composition was determined by aerial and ground counts in conjunction with nesting studies. In 1953 there were 800 geese in the study area, 400 of which were breeding birds. In 1954 there were 1,075 geese in the area, 432 of which were breeding birds. In 1953, 225 nests were located, 25 of which were believed to be renests. In 1954, 254 nests were located, and 38 of these were designated renests. Data indicated that 30 to 40 per cent of unsuccessful pairs made renesting attempts. Over 90 per cent of all nests were on islands; small islands supported a greater nesting density per acre than did large islands. In 1953, 73 per cent of 199 known-fate nests were successful, and in 1954, 51 per cent of 224 such nests were successful. Taking renests into consideration, it was estimated that 82 per cent of breeding pairs were successful in 1953, and 60 per cent of breeding pairs were successful in 1954.

The most noticeable specific cause of nesting failure appeared to be predation by crows, but such predation often followed desertion. Desertion was probably the primary cause of nest failure in many cases recorded as predation. Desertion was caused by inclement weather, human disturbance, and unknown factors. The low nesting success in 1954 was probably largely due to severe weather at the height of the laying period. A relationship was noted between clutch size, nesting success, and type of nesting cover used.

In both years over 85 per cent of the eggs in successful nests hatched. Average hatch in 119 successful nests was 5.14 young per nest in 1953 and 4.64 young per nest in 101 successful nests in 1954. Average hatch in all nests was 3.53 in 1953 and 2.22 in 1954. On the basis of mean hatch in known-fate nests, it was calculated that 796 goslings hatched in 1953 and 594 goslings hatched in 1954.

Eggs were injected with dye to color-mark the young. Observations of these marked broods showed that broods left the nest about 48 hours after hatching and traveled 2 to 10 miles to reach brood-rearing areas in shallow parts of the lake. There was a tendency for broods to combine on crowded brood-rearing areas. In some of these areas average brood size increased by as much as 75 per cent during the brood period. Because of this brood grouping, gosling mortality could not be estimated from regression in average brood size. Mortality of goslings was less than 10 per cent except in the Polson Bay area of Flathead Lake, where mortality was over 25 per cent. Productivity was estimated on the basis of the number of young reaching the flying age in July. In 1953, 200 breeding pairs produced about 634 young, an average of 3.16 young per pair. In 1954, 216 pairs produced 496 young, an average of 2.32 young per pair.


## LITERATURE CITED


CRAIGHEAD, F. C., JR. AND J. J. CRAIGHEAD. 1949. Nesting Canada geese on the upper Snake River. J. Wildl. Mgmt., 13:51-64.

DOW, J. S. 1943. A study of nesting Canada geese in Honey Lake Valley, California. Calif. Fish and Game, 29:3-18.

ELDER, W. H. AND NINA L. ELDER. 1949. Role of the family in the formation of goose flocks. Wilson Bull., 61:133-140.

EVANS, C. D. 1951. A method of color marking young waterfowl. J. Wildl. Mgmt., 15:101-103.

HANSON, H. C. AND R. H. SMITH. 1950. Canada geese of the Mississippi flyway with special reference to an Illinois flock. Bull. Ill. Nat. Hist. Surv., 25(3): 67-210.

MILLER, A. W. AND B. D. COLLINS. 1953. A nesting study of Canada geese on Tule Lake and Lower Klamath National Wildlife refuges, Siskiyou County, California. Calif. Fish and Game, 39:385-396.

NAYLOR, A. E. 1953. Production of the Canada goose on Honey Lake Refuge, Lassen County, California. Calif. Fish and Game, 39:83-94.

—— AND E. G. HUNT. 1954. A nesting study and population survey of Canada geese on the Susan River, Lassen County, California. Calif. Fish and Game, 40:5-16.

PATTERSON, R. L. AND R. M. BALLOU. 1953. The status of the Canada goose in Wyoming. Wyo. Wildl., 17 (8):4-14, 36.

REARDON, J. D. 1951. Identification of waterfowl nest predators. J. Wildl. Mgmt., 15:386-395.

WILLIAMS, C. S. AND W. H. MARSHALL. 1937. Goose nesting studies on Bear River Migratory Bird Refuge. J. Wildl. Mgmt., 1:77-86.

—— AND ——. 1938. Survival of Canada goose goslings, Bear River Refuge, Utah. J. Wildl. Mgmt., 2:17-19.


Received for publication October 21, 1955.

# ANNUAL SURVIVAL OF MASSACHUSETTS MALE WOODCOCKS[1]

*William G. Sheldon*

U.S. Fish and Wildlife Service, Amherst, Massachusetts

This is a preliminary report on the annual survival of American woodcocks (*Philohela minor*) studied in Massachusetts. To understand the population phenomena of any species of game animal, it is basic to have knowledge of the annual proportion of yearlings to adults in its breeding population. Since 1949, the Massachusetts Cooperative Wildlife Research Unit has conducted intensive trapping and banding studies of woodcocks in central Massachusetts (Sheldon, 1952, 1953a and b, 1954, 1955a and b). The principal study areas were in Quabbin Reservation, about 20 miles east of Amherst. Previous studies on sex and age ratios of American woodcocks are limited. Greeley (1953) analyzed these data for 209 fall-shot Wisconsin woodcocks. Mendall and Aldous (1943) presented findings on sex ratios, but little on age ratios. Lack (1943) has analyzed population turnover on the European woodcock (*Scolopax rusticola*).

Results presented in this paper stem from the records of 570 captures over a period of six years (1950-1955). There are 128 return records involving 86 birds. (In this paper, a "return" refers to a bird recaptured in the general area of original capture the year or years following banding. A "repeat" refers to a bird recaptured the same spring it was banded. A "recovery" refers to a bird killed by hunting in an area remote from the study areas.) With the exception of three hunter recoveries, all the data on survival are based on retrapped male birds. Only the records of captures on singing grounds most consistently trapped are presented, although many other captures have been made during the period of the study. Analysis has been confined to the returns of approximately 2,600 trap nights. In all, 188 singing grounds yielded data for this report.

The findings are based on the number of retrapped birds caught in successive years on specific singing fields. The validity of such results rests on the homing behavior of returning male birds, trapping efficiency, the stability of the breeding population from one year to the next, and the adequacy of the sample. Until a practical technique is developed to age birds quickly in the hunter's bag, as is done with other game species, it is doubtful that a statistically reliable sample of true age ratios will be recorded. Since Lack (1954) and others have shown that young of the year of many species are more subject to mortality during migration than adults, data on spring returns one year after initial capture will provide a better yardstick to measure the surviving breeding population than fall age ratios. This survival study is supplemented by current work in the Massachusetts research areas on the effect of vegetative changes on breeding populations, and an analysis of sex and age ratios of a summer resident population.

## Homing of Breeding Males

The detailed behavior of male birds in the spring has been discussed elsewhere (Sheldon, 1953b). It was shown that male birds quite commonly use more than one singing ground in the spring. Erratic movements of males in the breeding areas are one of the important sources of possible error in interpreting survival on the basis of retrapped birds. Returning birds are frequently missed.

Although the homing behavior of breeding males is such that the males usually return to the general vicinity of former breeding sites, it has not necessarily proved valid to assume that they return to the same site in Massachusetts.

Of 84 male woodcock returns, 32 per cent returned to original capture sites. Forty-nine per cent were recaptured at distances up to a mile away from original banding sites. Fourteen per cent of the returns were retaken between 1.1 miles and 2.5 miles from their initial capture sites (Table 1). Four additional birds were retrapped at distances exceeding 2.5 miles. The greatest distance separating different years' capture sites of the

[1] A contribution of the Massachusetts Cooperative Wildlife Research Unit jointly sponsored by the U.S. Fish and Wildlife Service, the Massachusetts Division of Fisheries and Game, the University of Massachusetts, and the Wildlife Management Institute.

TABLE 1. — MAXIMUM DISTANCES MOVED BY 84 MALE WOODCOCK, BASED ON RETURNS BETWEEN ANY TWO SINGING GROUNDS

| Distance in Miles | Number of Birds | Percentage |
|---|---|---|
| 0 | 27 | 32 |
| 0.1 – 0.25 | 11 | 13 |
| 0.26 – 0.5 | 15 | 18 |
| 0.6 – 1 | 15 | 18 |
| 1.1 – 1.5 | 6 | 8 |
| 1.6 – 2 | 3 | 3 |
| 2.1 – 2.5 | 3 | 3 |
| over 2.5 | 4 | 5 |

same bird was seven miles.

Twenty-seven of the returns were caught on only one singing ground in succeeding years, 49 were caught on no more than two different singing grounds, while the remainder were taken at more than two singing grounds (Table 2).

TABLE 2. — TOTAL NUMBER OF SINGING GROUNDS USED BY 85 RETURNING MALE WOODCOCKS

| Number of Singing Grounds Used | Number of Birds |
|---|---|
| 1 | 27 |
| 2 | 49 |
| 3 | 7 |
| 4 | 0 |
| 5 | 2 |

These data illustrate how easily birds may be missed during retrapping efforts. A male captured on a singing site is not necessarily the regular occupant. Sixty additional males were trapped at various singing sites which had already yielded one bird the same season. Three separate males were trapped the same spring on several sites, while in one singing field five different males were trapped on five successive nights.

Lack (1954) has cited studies made on adult mortality estimated by returns of banded birds where the male shifts breeding territories in successive years. He cites as examples the pied flycatcher (*Muscicapa hypoleuca*) in Finland, the European robin (*Erithacus rubecula*), and the redstart (*Phoenicurus phoenicurus*). He concludes this method of estimating survival is open to error, though the error may be small.

### HOMING OF FEMALES AND CHICKS

Although the three records that indicate homing behavior of chicks and females do not enter the calculations on survival, they are of interest. One male chick banded on the nest in early May 1952 was recaptured the following April while performing on a singing ground 200 yards from its hatching site. A female chick banded in May 1951 was recaptured 350 yards from its banding site in April 1953. Examination of the cloaca suggested the hen had begun a clutch. An adult female caught in a funnel trap three times during June and July 1953 was recaptured three-quarters of a mile away in a Japanese mist net in August 1954.

### TRAPPING EFFICIENCY

The important question to be answered in considering trapping efficiency is what percentage of the breeding males present on the study areas is missed each year.

Each year's trapping effort was measured on the basis of trap nights per site. Although approximately the same number of sites was trapped from 1951 to 1954, accurate trap-night records were not available on a number of sites trapped by outside cooperators. Those sites on which accurate records were kept indicate the annual trapping effort was about the same and ranged from 4.9 trap nights per site in 1951 to 4.7 trap nights per site in 1954 (Table 3). Trapping activity in 1955 was reduced to only 3.5 trap nights per site. Returns for 1955 are not comparable to returns in previous years because of reduced trapping effort and a sharp population drop on the trapping areas.

TABLE 3. — AVERAGE TRAP NIGHTS PER SINGING SITE, 1951-1954

| Year | Sites | Total Trap Nights | Average Trap Nights per site |
|---|---|---|---|
| 1951 | 108 | 530 | 4.9 |
| 1952 | 122 | 570 | 4.8 |
| 1953 | 87 | 421 | 4.8 |
| 1954 | 82 | 384 | 4.7 |

Evidence presented later indicates that the traps captured between 50 and 60 per cent of the breeding males present in the trapping areas. The detailed methods of trapping have been discussed elsewhere (Sheldon, 1955b).

### POPULATION

Relative stability of a population from one year to the next must be proved or assumed in order to calculate survival with any con-

fidence. Among upland game birds, the woodcock is a species which is not adaptable to cover changes as it requires a well-defined type of habitat to thrive. When the breeding population rises or falls from one year to the next, the biologist is faced with the problem of determining whether these changes reflect the numerical status of the population over at least part of its range or whether they reflect local changes in amount of suitable breeding cover.

Sufficient cover change to affect woodcock breeding populations can only become apparent over a period of years. It is true, however, that significant cover changes can occur more rapidly for woodcock than for most other species. The study areas on which the survival data have been gathered in Massachusetts are sufficiently diversified to test the effect of vegetative changes on woodcock populations.

Ninety-six of the singing grounds are located in a protected reservoir area which has been undisturbed for 20 years. During the first 10 years of protection, most open fields were planted to red pines (*Pinus resinosa*) and white pines (*P. strobus*). This has accelerated normal succession. The whole environment has been rapidly growing beyond optimum woodcock habitat. Although some singing fields have been abandoned because they became closed out by vegetation, this is not considered the primary limiting factor. There are still sufficient singing areas, but the entire habitat including feeding, resting, and nesting areas is less favorable. Evidence of this will be treated elsewhere. During the early years of the study (prior to 1952), a maximum of 74 of the 96 singing grounds were occupied in this area in one season. The number of occupied singing grounds fell off rapidly after 1952 so that in 1955 only 43 singing grounds were in use. Further evidence that vegetative change has been the responsible factor is the population trend on another study area in the same reservoir area that has been regularly cleared by cutting for several years. Twenty-eight additional singing grounds considered in this study are located there. Although conclusive evidence is lacking, it is believed the cutting operations have improved it as woodcock habitat since the highest breeding population was recorded in 1955. Sixty-four singing grounds are in scattered locations in the vicinity of Amherst, and have been trapped for several years by the same outside cooperators. These border on farming country, and have remained relatively unchanged.

Sixty-nine of the return records came from the reservoir areas where there has been a deterioration of habitat due to vegetative changes. These are included in the return records for all the study areas.

Possible population changes have been depicted for all the study areas combined by tabulating for each trapping season the number of former singing grounds that were currently unoccupied. If, for example, 10 grounds investigated in 1952 were found unoccupied although used in 1951, such areas were assumed to denote a population drop. If, however, five new grounds were occupied in 1952 over the same routes that were trapped in 1951, these were subtracted from the 10 unoccupied grounds leaving a net decrease of five rather than 10 grounds. These are tabulated as net abandoned singing fields in Table 4. Each year a few new singing grounds were found, so that by 1955 singing fields used for at least one year amounted to 130. It should be emphasized that, in this paper, a shortage of singing fields is not considered as a limiting factor in the study areas. The results of this analysis are presented in Table 4.

A similar case was found by Nice (1937) in her studies of the Song Sparrow (*Melo-*

TABLE 4. — NET NUMBERS OF SINGING FIELDS ABANDONED ON STUDY AREAS, 1952-1955

| Year | Singing Grounds Investigated* | Number of New Grounds Occupied over Routes Trapped in Previous Years | Number of Formerly Occupied Grounds Not Used | Net Abandoned Singing Fields |
|---|---|---|---|---|
| 1951 | 105 | — | — | — |
| 1952 | 112 | 7 | 16 | 9 |
| 1953 | 123 | 17 | 42 | 25 |
| 1954 | 128 | 14 | 61 | 47 |
| 1955 | 130 | 9 | 66 | 57 |

* Grounds visited several times to determine if bird was present. If a bird was present, the site was trapped.

*spiza melodia*) in Ohio. In the late years of her studies, much of the rough vegetation was destroyed, and only 25 per cent of banded breeding males returned, as compared with 55 per cent in the first three years the birds were banded. In this case, the evidence indicated that a fair proportion had not died, but had shifted their breeding territories elsewhere.

## SURVIVAL CALCULATIONS

Listed by years, singing-ground records included the following data: (1) number of birds captured; (2) number of sites unoccupied; (3) occupied sites where the birds were not captured; (4) whether or not investigated to determine presence of birds; (5) trap mortalities; and (6) returns with an appropriate symbol for the year class and a number to indicate the individual (since several returns were caught more than once). Thus, each site has a complete record, and one year's results can be compared with other years.

Certain sites could not be investigated in some years for various reasons. Such sites were not trapped nor was it known if they contained a bird. If one of these sites had a captured bird, for example in 1950, but could not be investigated in 1951, that particular 1950 capture was withdrawn from the 1950 total of captures on which returns were based. Since the site was not visited or trapped, there was no method of ascertaining whether a bird had returned.

In those cases where there was failure to capture a bird on an occupied site which had yielded a bird the preceding year, a more complicated interpretation was involved. The chances that any uncaptured bird was a return had to be determined. In 210 instances, birds were caught on a site that yielded a bird the preceding year. Sixty-nine (31 per cent) of such captures were returns. It appears logical, therefore, that 31 per cent of the birds present but not captured on those occupied sites that had yielded a bird the preceding year were returns.

Trap mortality was not considered normal mortality since death was due to exposing trapped birds to predators or to hot sun for several hours. Such mortality amounted to approximately 5 per cent of the total captures. A captured bird found dead in the trap was not included in the total of captured birds for any year class on which returns were calculated. The term year class in this paper refers to the year in which an adult bird of unknown age was captured.

There were several instances of returns captured that belonged to an earlier year class. For example, a 1950 bird that had not been recaptured in 1951 might well have been recaptured in 1952. This bird was obviously alive in 1951, although not caught. In calculating the survival of all 1951 birds captured one year after banding, an additional bird is added to this total of captured birds, and the 1950 bird is considered as also belonging to the 1951 class. Birds that survived over several years may be included in several year classes.

The unadjusted survival in subsequent years after banding is depicted in tables 5 and 6. Table 5 includes the data on many birds captured two or more years in succession.

Because of a serious population drop beginning in the spring of 1953, it would appear more valid to confine survival calculations to the banded classes of 1950 and 1951. As can be observed from the data of Table 6, the chances are good that even with a reduced population, additional survivors from the classes of 1953 and 1954 might well be retaken. Returns in 1955 have little meaning because of the reduction of trapping effort and the serious decline in the size of breed-

TABLE 5. — TOTAL UNADJUSTED SURVIVAL IN SUBSEQUENT YEARS AFTER BANDING AS SHOWN BY RETURNS, 1950-1955

| Year | Number Banded | 1951 | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|---|---|
| 1950 | 43 | 24[1] | 10 | 5 | 5 | 0 |
| 1951 | 124 | — | 48[2] | 16 | 7 | 1 |
| 1952 | 136 | — | — | 30 | 10 | 2 |
| 1953 | 91 | — | — | — | 20 | 4 |
| 1954 | 84 | — | — | — | — | 8 |

[1] Includes one hunter recovery shot in fall of 1951.
[2] Includes two hunter recoveries shot in fall of 1952.

TABLE 6.—UNADJUSTED RETURNS OF SEPARATE BIRDS IN EACH YEAR CLASS

| Year Banded | Number Banded | 1 Year Later Only | 2 Years Later Only | 3 years Later Only | 4 years Later Only | 5 years Later Only | Totals |
|---|---|---|---|---|---|---|---|
| 1950 | 43 | 18 | 4 | 1 | 1 | 0 | 24 |
| 1951 | 124 | 36 | 8 | 3 | 1 | — | 48 |
| 1952 | 136 | 24 | 5 | 1 | — | — | 30 |
| 1953 | 91 | 18 | 2 | — | — | — | 20 |
| 1954 | 84 | 8 | — | — | — | — | 8 |

ing populations on the study areas.

Without adjustment the trapping results and three hunter recoveries indicate a survival one year after banding of 56 per cent for the class of 1950, and 39 per cent for the class of 1951 (Table 5).

Inspection of Table 6 shows that six of the 24 birds known to have survived one year after banding in 1950 were missed in the spring of 1951. One of these was killed by a hunter in the fall of 1951. Twelve of the 48 birds from the banded class of 1951 known to have survived in the spring of 1952 were missed during that year. It is clear that the chances of catching a bird two years after banding are less than half as great as they are one year after banding. Although life expectancy apparently increases in those birds returning the first year following migration, the chances of catching the returns diminish with each succeeding year.

The crux of the problem is to make a conservative estimate of the returns missed in trapping one year after banding. The additional number of returns caught two years or later after banding might be doubled and added to the number caught one year after banding as an estimate of annual survival. Thus, in the case of the 1950 class, the estimated survival in 1951 would have been 30 instead of 24. In the 1951 class, the estimated survival in 1952 would have been 60 instead of 48. Such a method is crude, but the results of trapping suggest that these figures would represent a reasonable estimated minimum survival.

Fortunately, other data were gathered during the study to provide the basis for a sounder calculation.

In the springs of 1951 and 1952, retrapping was conducted in the latter part of May on singing grounds yielding birds approximately a month to six weeks earlier in the spring. The results provided interesting data on movements of singing males (Sheldon 1953b) and also afforded a method of estimating trapping success by employing the Lincoln Index.

Of 25 birds retrapped in 1951, 15 were repeats of birds banded a month earlier, and 10 were new birds not previously captured. Of 21 birds retrapped in the spring of 1952, 11 were repeats, 9 were new birds, and one was a return missed earlier in the year.

The following calculations are based on three major assumptions. The first is that there is the same number of birds present on the trapped grounds in May as a month earlier in April. The second is that birds banded a month earlier are as susceptible to trapping as new birds. It must also be assumed that the sample of the population is random.

At least two of these assumptions are valid. Studies during the six years indicate that in the study areas the majority of the resident breeding population arrives before trapping begins (Sheldon 1952, 1953b). In fact, all the evidence indicates that returns are among the earliest arrivals. For example, one return captured in May 1952, but missed earlier in the year, was originally caught March 30, 1951. Several birds recaptured in May in both years were also caught in late March or early April. Migration takes place in the Connecticut River valley, and spring arrivals at these lower elevations precede arrivals on the trapping grounds by two weeks or more. The question is posed as to whether birds hatched the previous year arrive on the breeding grounds after the older birds. The only positive evidence on this was the capture of a male banded as a chick the year before. This return was occupying a singing ground at least as early as April 4, and may well have arrived several days earlier.

On the second point, there are many records of birds having been retrapped two nights in succession. Some birds have been caught five times the same spring. The indication is that, having once been trapped, a bird is as susceptible to retrapping a month later as an untrapped bird.

It is believed that the sample is a fair representation of the entire population trapped. As with many samples of this kind, it is virtually impossible to assess its validity with accuracy. Trapping on all the study areas was stopped on approximately May 15. About a week remained during which the males were still active. Retrapping could only be conducted on those grounds that yielded birds up to about April 20. Retrapped samples were not obtained from singing grounds outside Quabbin Reservation. Sixty-five singing grounds that yielded birds in April were retrapped. In most instances, only one trap night was expended for each site. The May effort is not comparable to the April effort, but this does not affect the validity of the sample, since the same effort in May was expended to recapture banded birds as to capture new birds. The tabular results on which the following analysis is based are presented in Table 7.

An answer is sought to the total population available to the traps on the singing grounds. Using the Lincoln Index, let $r$ equal the number of marked animals in the retrapped sample of $n$ animals, and let $m$ equal the number of animals that were originally marked. The calculated total of male birds present would be T in the expression $T:m = n:r$. Thus for 1951 we have

$$\frac{T}{25} = \frac{25}{15}$$

$$T = 41.6$$

and for 1952,

$$\frac{T}{22} = \frac{21}{11}$$

$$T = 42$$

These data suggest that 15 (60 per cent) of the birds available to the traps were captured in 1951 during the trapping period before the retrapped sample was taken. On the basis of the sample, 11 (52 per cent) of the birds available to the traps in 1952 were estimated to have been taken prior to retrapping.

Referring to Table 6, the 124 birds listed as captured in 1951 include the 10 unbanded birds captured in the retrapping period. If the 114 birds caught prior to taking the retrapped sample represent 60 per cent of the birds available to the traps, the estimated population of males present would be 190. By the same method of calculation, the estimated total for 1952 possible captures would be 238.

Of the 114 birds captured in 1951, 18 (16 per cent) were returns. Since 40 per cent of the males present were missed, the estimated returns would be 16 per cent of 190 birds, or 30. This would indicate a survival in 1951 of 69 per cent of the 43 birds banded in 1950. Similarly, the calculated survival in 1952 of the 124 birds banded in 1951 would be 66 birds (53 per cent).

The confidence limits of these results were tested at the 95 to 5 level as suggested by Adams (1951). Clopper and Pearson's confidence belt graphs indicate confidence limits that are too broad to be applied to the results of this study. Adams points out that where the sample ratio is 0.5 or greater, the confidence belts err by 29 per cent. In this study, the sample ratio for 1950 returns is 0.6 and for 1951 returns, 0.52. In working out the results, for example, the confidence limits of the 30 calculated returns for the 43 birds banded in 1950 would be between 22 and 45. Twenty-four birds were known to have survived, and 45 would indicate an impossible return of more than 100 per cent. The adjusted survival rates as presented in Table 8 are based on the Lincoln Index.

The survival figures based on the Lincoln Index of the retrapped sample are not far from the best estimate one can calculate from the foregoing data. It is highly probable that the estimated return for the 1951 class is somewhat too low. The 1950 class was exposed to two years of intensive trapping, whereas the 1951 class was exposed only to one year of intensive trapping before the drop in population occurred in 1953.

In summary, the woodcock studies in

TABLE 7. — RETRAPPING RESULTS ON MASSACHUSETTS STUDY AREAS, 1951-1952

| Year | Number of Singing Grounds | Number of Birds Banded in April | Number of April-banded Birds Captured in May | Number of New Birds Captured in May | Number of Returns Missed in April but Captured in May |
|---|---|---|---|---|---|
| 1951 | 23 | 25 | 15 | 10 | 0 |
| 1952 | 21 | 22 | 11 | 9 | 1 |

Massachusetts suggest that between 55 and 60 per cent of the adult male woodcocks captured in the spring return a year later.

Table 6 includes data suggesting survival of birds two years and later after banding. The population decline beginning in 1953 precludes the accuracy of predicting survival greater than one year after banding. Data for the 1950 class might be considered accurate up to the year 1952, but the sample is small.

The results are of interest when compared to the findings of two other investigators. Greeley (1953) examined 209 fall-shot Wisconsin woodcocks and aged them by inspecting the bursa of Fabricius. He found the population to be composed of 44 per cent juveniles and 56 per cent adults. From a sample of 203 European woodcocks banded as young, Lack (1943) worked out the survival over a period of years and calculated that 63 per cent of the adults alive in summer survived a year later. Since this species produces two broods a year with about double the breeding potential of the American bird, the implication is that it sustains a heavy juvenile mortality.

It is actually unknown at what time, in the American woodcock year, first-year birds achieve the same instantaneous mortality rate as the adults. It is possible that in so precocious a species as the woodcock, this stage is reached in late summer before the onset of migration.

From these data a life equation can be worked out, and it is proposed that there is an even sex ratio for the following reasons. Other investigators including Mendall and Aldous (1943) and Greeley (1953) have reported a preponderance of hens in fall-shot birds. Glasgow (1953), banding woodcocks on their wintering grounds in Louisiana, has also captured considerably more females than males. The weakness of these data is that no sex ratios have been gathered from a known resident population. Furthermore, Mendall and Aldous (1943) offer some evidence that there may well be some sex segregation during migration. The same authors state that it is highly likely that at hatching the sex ratio is even. Glasgow (1953) reports that hens are easier to net than cocks. He also presents solid evidence that, in the spring migration, the cocks leave as much as two weeks before the hens. Most of the birds available for netting in February are females.

The present findings suggest an even sex ratio. During the years of this study a number of hens have been trapped and netted. Field notes indicate that the females are less alert than the males and not as wild. After a hen has been banded it can be placed twenty feet away on the ground. If it is held in a light beam, a bander can readily go over and pick the bird up again. This is not the case with cocks, which flush almost immediately after release whether held in a beam of light or not. I would also suggest that a hen bird offers a better target and often appears to be of slower flight. Other evidence is provided by the sex ratio of juvenile birds netted on their rearing grounds during the summer months. Sexes were separated on the basis of bill length, width of primary feathers and weight, when obtainable. Of 67 juveniles netted and aged in the summers of 1954 and 1955, 42 were males and 25 were females, giving a sex ratio of 168 males to 100 females.

In the life equation, losses of adult males have been assumed to be as great as females. Many species of waterfowl and gallinaceous birds show an excess of males, apparently due to female mortality while nesting and caring for young. Predation by great horned owls (*Bubo virginianus*) on singing male woodcock has been observed in Massachusetts. Also, remains of singing birds have occasionally been found on the performing fields. It is probable that they are as vulnerable to predation as females, which are not easily flushed from their nests, and which rear their young to a flying age 14 days after hatching. It is possible, of course, that there is greater hen mortality in areas where spring fires are prevalent.

TABLE 8. — ADJUSTED ESTIMATE OF SURVIVAL ONE YEAR AFTER BANDING OF 1950 AND 1951 CLASSES

| Year | Birds Captured | Number Known to Survive One Year After Banding | Adjusted Estimate | Percentage Survival |
|---|---|---|---|---|
| 1950 | 43 | 24 | 30 | 69 |
| 1951 | 124 | 48 | 66 | 53 |
| Totals | 167 | 72 | 96 | 57 |

With these assumptions and using Aldous and Mendall's (1943) data on clutch size and nest success, 100 adults will produce 139 chicks. From the time of hatching until the following breeding season, there will be a mortality of 96 chicks and 43 adults. The surviving breeding population a year later will be comprised of 57 adults and 43 yearlings.

## LONGEVITY

In estimating an animal's breeding potential, longevity is a factor of importance. It appears that, in the wild, American woodcocks seldom exceed five years of age. Five individuals in the Massachusetts study were known to survive a minimum of five years. Using Lack's (1954) formula of $\frac{2\text{-}m}{2m}$ where $m$ equals percentage of annual mortality, the average expectation of further life of an adult American woodcock would be 1.8 as compared with 2.2 years for the European woodcock. The average life expectancy of a hatched chick would be 0.95 years.

## ACKNOWLEDGMENTS

I am indebted to the following individuals who have reviewed all or the parts of this manuscript: Frederick Greeley, Joseph Hickey, H. A. Hochbaum, Daniel L. Leedy, Walter Crissey, J. W. Aldrich, Howard Mendall, and R. E. Trippensee. Many of the University wildlife students have assisted from time to time in the field work. Ethan Howard, Jr., has worked regularly as a field assistant since the beginning of the study. Outside cooperators have included Gardner Hobart, Gordon Hobart, and T. D. Ford.

## SUMMARY

Survival of male woodcocks was studied by means of spring trapping from 1950 to 1955 in Massachusetts. Data on 128 return records of 86 individual banded adult male birds and on 188 singing grounds formed the basis for this report. Validity of results depended upon trapping efficiency, homing behavior of returning male birds, and stability of population from one year to the next. Analysis of homing of male birds, and trapping efficiency suggested that traps captured between 50 and 60 per cent of the breeding males in the general vicinity of the trapping grounds. Vegetative changes on trapping grounds were considered to be responsible for a population drop first discernible in the spring of 1953. Abandoned singing grounds on the trapping grounds rose from 9 in 1952 to 57 in 1955. Because of the population drop, return data were confined to 43 birds banded in 1950 and 124 birds banded in 1951. Complete returns for all year classes are presented in tabular form. Analysis of all the data presented suggested a minimum annual survival of 57 per cent of male woodcocks. These data would indicate an annual mortality of 43 per cent of adults and 69 per cent of chicks.

## LITERATURE CITED

ADAMS, L. 1951. Confidence limits for the Petersen or Lincoln Index used in animal population studies. J. Wildl. Mgmt., 15:13-19.

GLASGOW, L. 1953. The American woodcock (*Philohela minor*) in Louisiana. School of Forestry and the Agric. Exp. Sta., Louisiana State Univ., Baton Rouge, Louisiana. 16pp. (mimeog.)

GREELEY, F. 1953. Sex and age studies in fall-shot woodcock (*Philohela minor*) from southern Wisconsin. J. Wildl. Mgmt., 17:29-32.

LACK, D. 1943. The age of some more British birds. Brit. Birds, 36:214-221.

——. 1954. The natural regulation of animal numbers. Oxford, Clarendon Press. 343 pp.

MENDALL, H. L. AND C. M. ALDOUS. 1943. The ecology and management of the American woodcock. Maine Coop. Wildl. Res. Unit, Orono, Maine. 201 pp.

NICE, M. M. 1937. Studies in the life history of the song sparrow, vol. 1. Trans. Linn. Soc. N.Y., 4:1-247.

SHELDON, W. G. 1952. Studies on breeding woodcock in Massachusetts. *In* Investigations of woodcock, snipe and rails in 1951. U.S. Fish and Wildl. Serv. Spec. Sci. Report—Wildl. No. 14, pp. 30-44.

——. 1953a. Report on woodcock investigations in Massachusetts—spring 1952. *In* Investigations of woodcock, snipe, and rails in 1952. U.S. Fish and Wildl. Serv. Spec. Sci. Report 1: Wildl. No. 18, pp. 28-29.

——. 1953b. Woodcock studies in Massachusetts. Trans. N. Amer. Wildl. Conf., 18:369-377.

——. 1954. Summary of Massachusetts woodcock studies, 1953. *In* Investigations of woodcock snipe, and rails in 1953. U.S. Fish and Wildl. Serv. Spec. Sci. Report—Wildl. No. 24, pp. 35-39.

——. 1955a. Massachusetts woodcock studies—1954. *In* Investigations of woodcock, snipe, and rails in 1954. U.S. Fish and Wildl. Serv. Spec. Sci. Report—Wildl. No. 28, pp. 29-33.

——. 1955b. Methods of trapping woodcocks on their breeding grounds. J. Wildl. Mgmt., 19: 109-115.

Received for publication November 23, 1955.

# BREEDING DENSITY AND PRODUCTIVITY OF MOURNING DOVES ON A COUNTY-WIDE BASIS IN GEORGIA[1]

*Jack I. Lowe*

University of Georgia, Athens

The need for information basic to the management of the mourning dove, *Zenaidura macroura* (Linnaeus), has stimulated investigation of populations both in the northern states where the dove is not hunted and in the southern and western states where it is a major game bird. Scattered studies suggest that there may be regional differences in the ability of dove populations to produce young, with the southeast ranking low. Large numbers of doves winter in Georgia, but the proportion raised in the state is unknown. The purpose of the present study was to obtain additional information both on the size of the breeding population in the Central Piedmont of Georgia and on the number of young doves produced annually. A second objective was to compare calling activity with density, as did McGowan (1953), in order to test further the standard call count as an index to breeding population size. Perhaps for the first time it has been possible to "calibrate" the call count and thereby estimate the total population of a whole county.

This study was suggested and directed by Dr. Eugene P. Odum of the University of Georgia, and made possible by a fellowship in the University's Wildlife Conservation Program, which is supported by funds provided by the Georgia Game and Fish Commission. Dr. James H. Jenkins of the Forestry School, University of Georgia, assisted in many phases of this study. Unpublished data on call counts for 1953 were provided by John B. Gentry, Marvin Provo, and Charles Lowe.

Although doves may take advantage of the long breeding season in captivity and raise as many as eight broods (Woodward, 1929), this is not usually the case under natural conditions. Doves in the northern states are reported to attempt at least three broods. McClure (1942) reported 5-6 young raised per pair per year in Iowa, where doves nest in large numbers. Nice (1943) believed that this estimate was too high since McClure may have underestimated the size of his breeding population. Austin (1951), on the basis of banding returns, estimated that Cape Cod doves produce 4.6 young per pair. In a study made on a North Dakota shelterbelt area, Boldt and Hendrickson (1952) found that 20 pairs produced an average of a little over three young per pair. Also working in North Dakota, Randall (1955) counted 259 young produced by an estimated population of 57 pairs in two areas, a production rate of 4.5 young per pair. The greatest number of active nests found in a single day was taken as the estimate of the adult population, which, as will be pointed out later, undoubtedly underestimates the population and thereby overestimates the production rate. In a recent study Cowan (1952) reported as high as 6.3 young per pair in a small dense colony in California. Swank (1955) found that seven pairs of marked doves on the Texas A. and M. campus reared an average of 6.7 young per pair. However, based on age ratios of birds taken in the fall by hunters Swank estimated 3.34 (in 1949) and 3.04 (in 1950) young per pair to be the average production for central Texas as a whole. Hopkins and Odum (1953) reported that Georgia doves in 1950 and 1951 produced only an average of 2.1 young per pair on ten 100-acre study areas scattered over the state. This low production rate was due only in part to a low nesting success, but mostly to the fact that doves made fewer nesting attempts than expected. In general, highest production has been observed in regions where doves nest crowded together in small areas; such crowded situations seem rarely to be the case in the southeast (*ibid.*). Very few attempts have been made to estimate both density and natality rate for extensive areas which include both nesting and feeding habitat.

[1] Presented in partial fulfillment of the requirements for the degree of Master of Science, Department of Zoology, University of Georgia.

## METHODS

This investigation was made on eight study areas of 150 acres each. In order to locate all breeding doves on each study area, 50 additional acres (the "buffer zone") surrounding each study area were censused. Seven of these study areas were located around stations 2, 3, 9, 10, 12, 16, and 20 on the 20-station Oconee County call-count route, which has been described and diagramed by McGowan (1952). The eighth study area (P-1) was located on a Madison County farm, which had been previously censused by Hopkins and Odum (1953). The seven study areas on the call-count route were selected because they represented low, average, and high levels of dove-population density as indicated by call counts of previous years.

Maps of the study areas were made from aerial photographs, additional details being added from ground survey. The maps were drawn to a scale of 1 in. to 660 ft. Mimeographed copies were made and carried into the field on each coverage of the study areas. On each day in the field one area was censused systematically, usually between the hours of 6:30 and 10 A.M. All doves seen or heard and nests found were indicated on the map by appropriate symbols. Forest edges, fence rows, hedgerows, and other habitat junctions were cruised in the same manner on each census. Occupied nesting sites generally became apparent after several visits to a study area, whether actual nests were found or not. A bird or pair consistently perched, calling, or otherwise associated with a potential nesting site was considered to represent a breeding pair. Each study area was censused about once every two weeks from March to September 1954. At the end of the investigation composite maps were made for each area and peak season density and number of young fledged ascertained. The same method was used to census some of the same areas in 1951 and 1952 by Hopkins and Odum and by McGowan.

During the time the study areas were being censused, early-morning call counts were carried out at weekly intervals. The route and procedure were the same as used by McGowan (1952, 1953). A call count required approximately two hours, with three-minute stops at each station and three minutes of driving between stations. The number of doves calling and the total number of calls were recorded for each of the 20 stations.

## RESULTS

*Call Counts.*—The results of call counts made by the author in 1954, together with similar data obtained on the same route by McGowan in 1951 and 1952, are shown in Fig. 1. Calling activity in both 1951 and 1954 remained at a low level in March and April, increased abruptly in early May and reached a gently sloping plateau in May and June. A gradual but persistent decline occurred between June and the end of July, after which the decline became more rapid. The 1952 counts showed the same seasonal pattern but the peak was not reached until the latter part of May. A few counts were made between May 21 and July 10 in 1953; as in 1952 the peak was not reached until late May. For purposes of comparison we shall speak of the May-June period of maximum calling as the "peak season plateau." Possible annual differences in the height of this plateau will be discussed later in connection with the data on breeding density.

*Population Density and Production of Young.*—Breeding density varied from 1.5 to 7 pairs per 150-acre study area with an average of 3.8 per 150 acres, or 2.5 pairs per 100 acres (Table 1). A total of 23 active nests actually found produced 25 young from a total of 46 eggs laid, a nesting success of 54 per cent. A study of breeding territories provided good evidence for the existence of 35 additional nests. Assuming that unfound nests had the same success as those observed, it was estimated that 35 additional young were probably produced on the eight areas. Therefore, the estimated production of young was 2.0 per pair (Table 1). Expressed in terms of area the production was estimated to be 60 young for the 1,200 acres or 5 young per 100 acres. In other words, five breeding doves produced about five young for each 100 acres of the sample of Piedmont farmland.

*Relation of Call Counts to Density and Productivity.*—In Fig. 2 the estimated number of pairs established on breeding territories and the total number of active nests that were found to contain eggs or young on each visit are plotted for all eight of the study areas combined (1,200 acres). The

TABLE 1. — SUMMARY OF ESTIMATED DENSITY AND PRODUCTION OF YOUNG ON EIGHT 150-ACRE STUDY AREAS IN 1954

| Area No. | Estimated Breeding Pairs | Nests Found | Number Successful | Young Produced | Known Young per Pair | Estimated Nests not Found | Est. no. Young Produced in Nests not Found* | Est. Total Young per Pair |
|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 4 | 3 | 4 | 1 | 4 | 4 | 2.0 |
| 3 | 2.5 | 0 | 0 | 0 | 0 | 6 | 6 | 2.4 |
| 9 | 3 | 3 | 0 | 0 | 0 | 4 | 4 | 1.3 |
| 10 | 4 | 2 | 1 | 2 | 0.5 | 5 | 5 | 1.8 |
| 12 | 5.5 | 6 | 4 | 8 | 1.5 | 4 | 4 | 2.2 |
| 16 | 1.5 | 0 | 0 | 0 | 0 | 2 | 2 | 1.3 |
| 20 | 2.5 | 2 | 1 | 2 | 0.8 | 3 | 3 | 2.0 |
| P-1 | 7 | 6 | 5 | 9 | 1.3 | 7 | 7 | 2.3 |
| Averages | 3.8 | 2.9 | 1.8 | 3.1 | 0.8 | 4.4 | 4.4 | 2.0 |

* Assuming 50 per cent success for nests not found.

peak of observed nesting activity in May coincided with the "peak season plateau" of the call counts as shown in Fig. 1. Also, the period of most active nesting, May through July, coincided with the total period of most active calling. Even if all the nests could be found, it is clear that not all pairs in residence would likely have active nests at any one visit because of the spread of the season and the high nest mortality.

A direct comparison of calling level and breeding density is made in Table 2, which

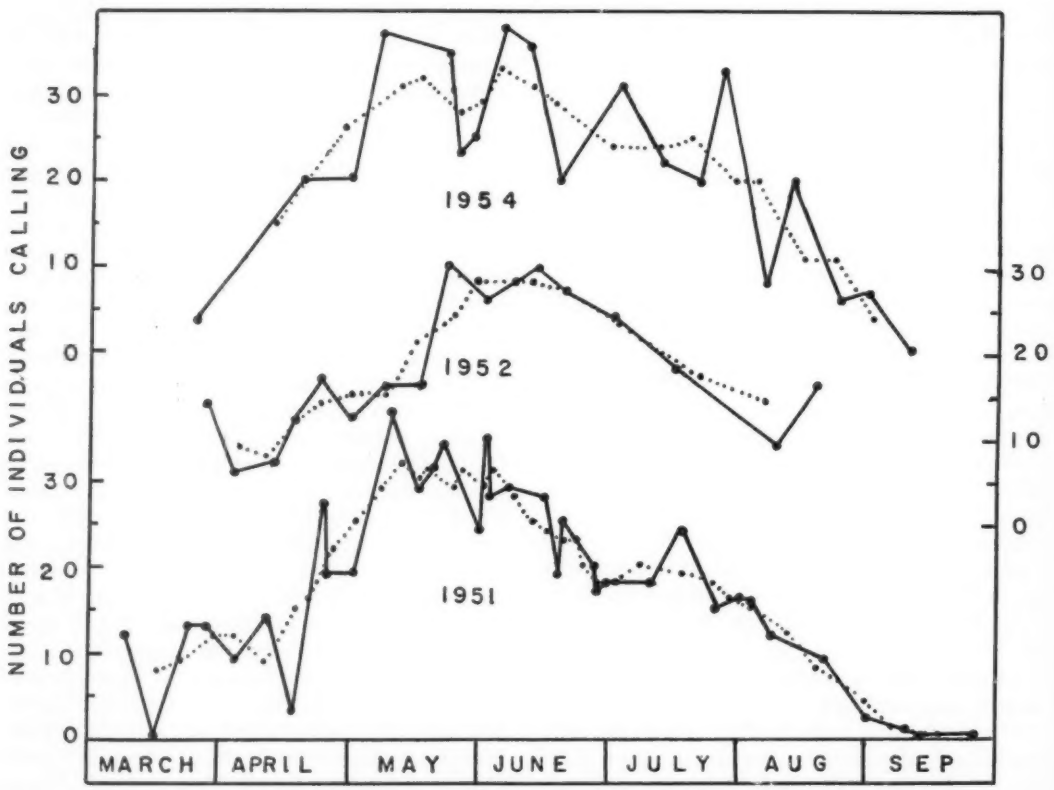



FIG. 1. Comparison of early morning call-count curves on the same 20-mile, 20-station route (Oconee County, Ga.) for three years. Smoothed curve (dotted line) represents moving averages of three.

includes all data so far obtained at stations located along the Oconee County route. Calling and density are well correlated, as shown by the rather consistent ratio of around two pairs of breeding adults per calling individual. As demonstrated by McGowan (1953), calling activity may be expected to be lower and more irregular at the last few stations on the route (as for example, 15-20) because the peak of morning calling activity is past when the observer reaches these stations. Therefore, it is not surprising that the ratios between calls heard and birds present at stations 16 and 20 were less consistent. However, the stations were selected to cover the whole route, so that the average of 1.74 pairs per calling bird (last column, Table 2) is probably representative of the route area as a whole.

In 1954, a peripheral "buffer" strip of about 50 additional acres was also censused. On area 2 it was observed that doves on this buffer area could definitely be heard from the call-count station located in the center of the 150-acre area. The coefficient of correlation between calls and birds on the 150 acres was almost identical with that between calls and birds estimated to be on the larger (approximately 200 acres) area ($r = 0.80$ and 0.81 respectively). Therefore, not enough birds beyond the 150-acre area were regularly heard to establish a better correlation with an area larger than 150 acres. Since McGowan (1953) found that 150 acres resulted in better correlation between calls and doves than did 100 acres, it would seem that 150 acres represent the approximate area on which doves are likely to be heard regularly at listening stations.

Since there is a consistent relationship between calling and density, and since about 150 acres appear to be in the range of a call-count station, it is now possible to estimate the average density for the entire 20-station call-count route. This has been done in Table 3 for the four years for which call-count data are available.

Estimates based on call counts appear to be consistent with those based on spot-mapping of study areas (Table 2). For example, both indicate that population density along the route was greater in 1954 than in 1952. If we compare only the four stations cen-

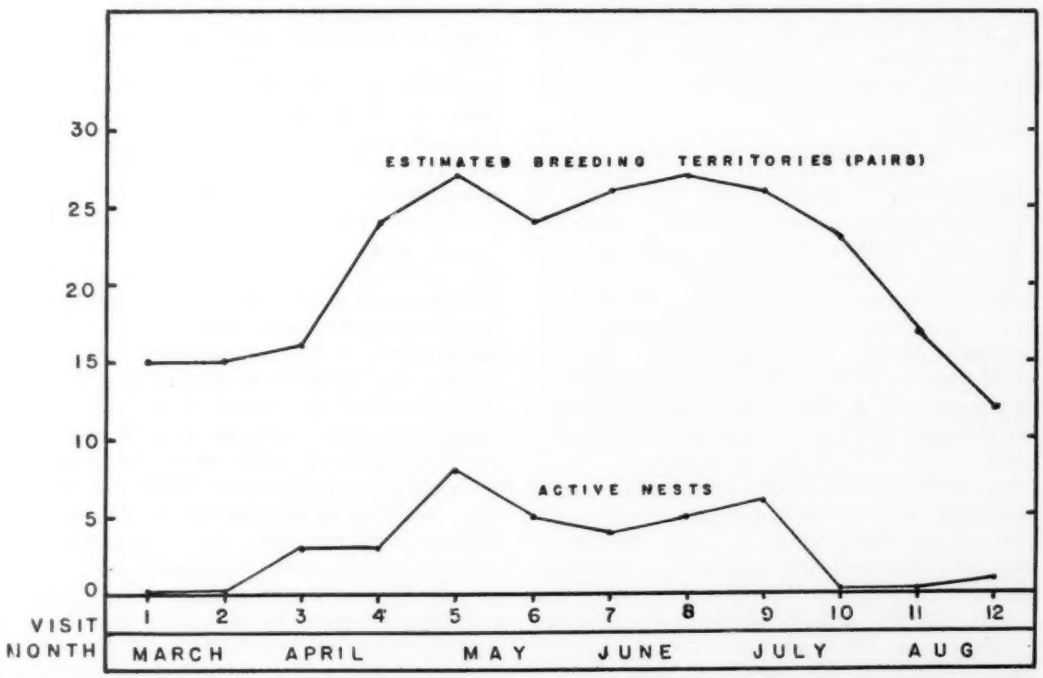



FIG 2. Relationship between population density and number of active nests that could be found on each of twelve visits to eight study areas having a total area of 1,200 acres.

TABLE 2. – RELATIONSHIP BETWEEN BREEDING DENSITY AND CALL INDEX (AVERAGE NO. BIRDS CALLING PER STATION VISIT) AT STATIONS ON THE CALL-COUNT ROUTE

| Year | Area | Observer | Breeding Pairs per 150 Acres | May-June Call Index | | Pairs per Calling Bird |
|---|---|---|---|---|---|---|
| | | | | No. Counts | Avg. Calls per Sta. | |
| 1951 | 10 | Hopkins and Odum | 4 | 17 | 2.60 | 1.54 |
| 1952 | 2 | McGowan | 3 | 8 | 1.28 | 2.19 |
| | 5 | McGowan | 2 | 8 | 1.47 | 1.36 |
| | 9 | McGowan | 3 | 8 | 2.00 | 1.50 |
| | 16 | McGowan | 2 | 8 | 0.50 | 4.00 |
| | 20 | McGowan | 0 | 8 | 0.50 | 0.00 |
| | Average–1952 | | 2.0 | | 1.15 | 1.81 |
| 1954 | 2 | Lowe | 4 | 6 | 1.67 | 2.39 |
| | 3 | Lowe | 2.5 | 6 | 1.33 | 1.88 |
| | 9 | Lowe | 3 | 8 | 2.67 | 1.12 |
| | 10 | Lowe | 4 | 8 | 2.00 | 2.00 |
| | 12 | Lowe | 5.5 | 8 | 2.33 | 2.36 |
| | 16 | Lowe | 1.5 | 8 | 1.00 | 1.50 |
| | 20 | Lowe | 2.5 | 8 | 0.33 | 0.76 |
| | Average–1954 | | 3.3 | | 1.62 | 1.72 |
| | Average of all data | | 2.85 | | 2.28 | 1.74 |

sused in both years, namely 2, 9, 16, and 20, the density was 2.0 in 1952 and 2.75 in 1954, a 37 per cent increase. The call index for these four stations increased from 1.07 to 1.42, or 33 per cent. The change in the call index for the entire route, however, was not so great.

## DISCUSSION

Coordinated studies of the call count as a census method for doves in 1951 indicated that the seasonal curve for early-morning counts was similar in form both in northern and southeastern states. For example, a peak in calling activity was reached at approximately the same time (late May to early June) in Wisconsin (Wagner, 1952), in Tennessee (Kerley, 1952) and in Georgia (McGowan, 1953). The curves for different years on the same route, as shown in Fig. 1, were quite similar in general shape. Characteristic features of the latter are the abrupt rise in the number of birds calling in May and the gradually sloping "peak season plateau" which lasts for about two months.

The results of the productivity studies made during this study were very similar to those obtained by Hopkins and Odum (1953). They used study areas both on the Coastal Plain and the Piedmont region of Georgia. On seven study areas (all but one being different from those used by this author) of 100 acres each, they found an estimated 34 pairs, which produced an estimated 2.1 young per pair. The breeding density of their study areas varied from one to nine pairs with an average of 3.3 pairs per 100 acres. At the time of this study they thought that the low production might be the result of an unfavorable year. However, now that another season's data have shown almost the same results (i.e. 2.5 pairs per 100 acres and 2.0 young per pair), it seems likely that a low production rate of about two young per pair is close to the actual natality of doves in Georgia. As was found by Hopkins and Odum in 1950-51, the low production rate in 1954 was due not to an unusually low nesting success, but to the fact that relatively few nests were actually attempted before April or after June.

One thing that must be considered when the breeding density of doves in Georgia is compared with that of doves in other parts of the country is the degree of nesting aggregation. Since nesting doves are relatively scattered in Georgia, study areas must be large. However, in other parts of the country where nesting cover is definitely a limiting factor, doves often nest in dense colonies. Some of the highest estimates of nesting success and productivity have come from the study of these dense colonies, as for example McClure's study in Iowa, Swank's study in Texas, and Cowan's study in California. McClure (1942) and Randall (1955) both considered the maximum number of active nests as representing the nesting population. As pointed out earlier in this paper, it is not likely that all pairs will have a nest active at any one time. Therefore, these authors probably underestimated the number of adults and thereby overestimated the number of young produced per pair. Cowan (1952) corrected for this source of error which he estimated to be about 14 per cent. Likewise, the figures showing high density in colonies can be misleading unless the area needed for feeding is considered (usually this area is completely unknown). Referring to Cowan's study again, he found as many as 16 pairs nesting on two acres of willows, but the over-all density of 2,500 acres, which included the colony, was only about 1.1 pairs per 100 acres. Thus, while the density and

natality were very high in the colony, the over-all density in the region was actually less than that of the 1,200 acres sampled in the present study.

Since estimates based on call counts which cover a large sample are consistent with those based on intensive studies of small areas, and since the study areas are more or less typical of the adjacent region, an estimate of density and the rate of reproduction was made for Oconee County. Data in Table 3 suggest that the dove population is remaining somewhat constant despite the low number of young that are apparently produced. Oconee County has about 120,000 acres, of which about 107,000 are in farmland of the type traversed by the 20-mile call-count route. If there were 2.33 pairs per 150 acres in 1954 (Table 3), then

TABLE 3. — ESTIMATE OF AVERAGE POPULATION DENSITY IN PAIRS PER 150 ACRES ALONG ENTIRE 20-STATION CALL-COUNT ROUTE BASED ON THE CALL INDEX

| Year | No. of Call Counts | Call Index | Estimated Density (Index × 1.74—seeTable 2) |
|---|---|---|---|
| 1951 | 17 | 1.32 | 2.30 |
| 1952 | 8 | 1.23 | 2.14 |
| 1953 | 8 | 1.05 | 1.83 |
| 1954 | 8 | 1.34 | 2.33 |

107,000 acres would contain 3,323 adults and in the late summer about the same number of juvenile birds, not counting, of course, migrants from other areas which begin coming into the region in late summer or early fall.

## SUMMARY

Breeding density and the number of young produced were determined on eight study areas of 150 acres each in the Central Piedmont of Georgia, and these data compared with standard call counts made in the same region. Similar data obtained by others in previous years were also available for comparison. An average of 2.5 pairs per 100 acres was found, which produced an estimated 2.0 young per pair per year, verifying the low production rate previously reported for the region. By relating nesting density and the call-count index, it was found that for each individual dove heard calling at a listening station in the center of the area there was an average of 1.74 pairs on each 150-acre study area. Using this ratio it was possible to estimate the average density for the entire 20-station route for four consecutive years as follows: 1951, 2.30; 1952, 2.14; 1953, 1.83; 1954, 2.33 (pairs per area of 150 acres). Since estimates based on call counts were consistent with those based on more intensive study of small areas, it was suggested that the dove population has remained fairly constant from 1951 to 1954 in Oconee County despite low production of young, and that 107,000 acres of farmland in the county had in the late summer of 1954 approximately 3,500 breeding adult doves and about the same number of locally produced juvenile doves.

## LITERATURE CITED

AUSTIN, O. L., JR. 1951. The mourning dove on Cape Cod. Bird-Banding, 22:149-174.

BOLDT, W., AND G. O. HENDRICKSON. 1952. Mourning dove production in North Dakota shelterbelts, 1950. J. Wildl. Mgmt., 16:187-190.

COWAN, J. W. 1952. Life history and productivity of a population of western mourning doves in California. Calif. Fish and Game, 38:505-521.

HOPKINS, M. N., AND E. P. ODUM. 1953. Some aspects of the population ecology of breeding mourning doves in Georgia. J. Wildl. Mgmt., 17:132-143.

KERLEY, C. 1952. The call-road count as an index to breeding populations of the mourning dove in east Tennessee. U.S. Fish and Wildl. Serv., Spec. Sci. Rept: Wildlife, 17:8-14.

MCCLURE, H. E. 1942. Mourning dove production in southwestern Iowa. Auk, 59:64-75.

MCGOWAN, T. A. 1952. An intensive study of the call count as a census method for mourning doves on the Georgia Piedmont. U.S. Fish and Wildl. Serv., Spec. Sci. Rept.: Wildlife, 17:4-7.

———. 1953. The call-count as a census method for breeding mourning doves in Georgia. J. Wildl. Mgmt., 17:437-445.

NICE, M. M. 1943. Review of "Ecology and Management of Mourning Dove" by H. E. McClure. Wilson Bull., 55:198-200.

RANDALL, ROBERT N. 1955. Mourning dove production in south central North Dakota. J. Wildl. Mgmt., 19:157-159.

SWANK, W. G. 1955. Nesting and production of the mourning dove in Texas. Ecology, 36:495-505.

WAGNER, F. H. 1952. Preliminary investigations on mourning dove index and survey methods in Wisconsin. U.S. Fish and Wildl. Serv., Spec. Sci. Rept.: Wildlife, 17:47-53.

WOODWARD, C. H. 1929. Long breeding period in captive mourning doves. Condor, 31:125-126.

Received for publication January 23, 1956.

# STIMULATING REGROWTH OF MOUNTAIN MAPLE FOR DEER BROWSE BY HERBICIDES, CUTTING, AND FIRE[1]

*L. W. Krefting, H. L. Hansen, and M. H. Stenlund*

U.S. Fish and Wildlife Service; University of Minnesota School of Forestry; Minnesota Division of Game and Fish, St. Paul, respectively

Overbrowsing by deer, which has been responsible for the depletion of their winter food supply, has been regarded by wildlife biologists as one of the most important problems in need of solution. While considerable attention has been given to the problem of adjusting the deer population so as to be in balance with the available winter browse, relatively little research has been done on methods of increasing deer browse.

Mountain maple (*Acer spicatum*) is a staple and preferred browse species over much of its range in the Lake States, northeastern United States, and southern Canada west to the Prairie Provinces (Fig. 1). It frequently attains a height of over 15 feet and a diameter of approximately 3 inches. The species has the ability to regenerate both by means of stem sprouts and root suckers and has a strong tendency to grow in clumps or colonies, especially if disturbed by browsing or cutting.

In 1935 and 1937, investigations on the effect of cutting shrubs and young trees to induce sprout growth for deer browse were conducted on the Superior National Forest. Mountain maple as well as other tree and shrub species were included in these tests and the results have been reported by Krefting (1941). In general, it was found that the quantity of available deer browse could be greatly increased by cutting the larger stems and thereby inducing regrowth (Fig. 2). A remeasurement in 1952 has shown that the amount of available browse remained high 16 years after cutting (Krefting, 1953).

Rapid postwar development in the use of such growth hormone herbicides as 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) for the control of both herbaceous and woody plants suggested that these materials might be useful in inducing regrowth for deer browse. These herbicides are not toxic to animals and also tend to be selective in their relative effects on different plants.

The objectives of the present study were to evaluate the effectiveness of several herbicidal, cutting, and fire treatments in inducing regrowth of mountain maple and to determine whether or not deer would browse on such regrowth.

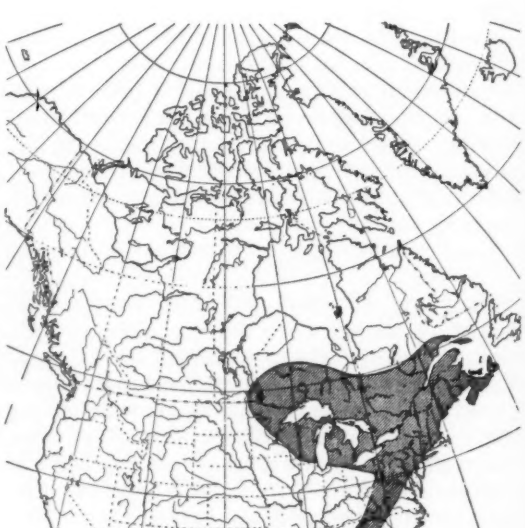


FIG. 1. Botanical range of mountain maple (*Acer spicatum*).

[1] The writers are greatly indebted to Cherng-jiann Shiue, Research Assistant, School of Forestry, for making the statistical analysis of the data.

Support for this project was also received through a Grant-in-aid of Research from the Graduate School of the University of Minnesota. Chemicals were furnished by the American Chemical Paint Company.

Paper No. 3528, Scientific Journal Series, Minn. Agricultural Experiment Station.

FIG. 2. Mountain maple regrowth 3 years after cutting with an axe.

## TREATMENTS

*Description of the Area.*—The tests to induce regrowth were made in the vicinity of Lutsen, Minnesota, along the north shore of Lake Superior and within the Jonvik deer yard. This yard covers a gross area of approximately 5,000 acres. The forest cover type is chiefly pole-size balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) with a scattered amount of large paper birch (*Betula papyrifera*), black spruce (*Picea mariana*), and aspen (*Populus tremuloides*). Balsam fir is the most abundant tree species in the understory. Of the shrub species, mountain maple is the most important and forms a large part of the deer's winter-browse supply. However, the deer-food situation is critical as the available supply was reduced by 50 per cent from 1940 to 1949 largely as a result of excessive browsing. This area was also one of those in which the cutting experiments of 1935 and 1937 were conducted.

*Chemicals Used.*—Previous investigations by Hansen and Ahlgren (1950) indicated that summer foliage sprays of both 2,4-D and 2,4,5-T (isopropyl esters) were moderately effective in killing the aerial stems of mountain maple and that considerable regrowth resulted. A study by Roe (1953) of the effect of 2,4,5-T (propylene glycol butyl ether ester) applied as a basal spray to this species indicated that clumps sprayed at time of bud burst had considerably greater regrowth than clumps similarly sprayed in the dormant season.

On the basis of these studies as well as other unreported observations on the use of growth hormone herbicides on other species and during various seasons of the year, it appeared that both 2,4-D and 2,4,5-T had possible value for use in inducing regrowth (Fig. 3). It also seemed that early spring was probably the most favorable season for getting a top kill of the aerial stems without killing the roots and preventing regrowth. In these tests the butoxy ethanol esters were used for both chemicals.

General experience with the use of these chemicals diluted in oil and water and applied to bark tissues has indicated that oil is far superior to water as a penetrant. Therefore, all chemicals used in these experiments were mixed in No. 1 diesel oil. Concentrations of 4, 8, 12, and 16 pounds AHG (acid equivalent per 100 gallons of diesel oil) were tried. Several tests of diesel oil alone were also included. The spray was applied until runoff from the bark occurred.

*Equipment.*—Two kinds of sprayers were used for the tests. All of the spraying in May 1954 and April 1955 was done using a plot sprayer developed at the School of Forestry for experimental use where carefully controlled applications are desired (Fig. 4). This sprayer has a pressure tank capable of holding air under pressures exceeding 300 pounds per square inch with an intake valve that enables filling from ordinary air compressors. The outlet pipe has a positive shut-off valve and a pressure-regulator valve that can be adjusted to release air at any predetermined pressure, in this case 35 pounds per square inch. A stainless-steel container of one-quart capacity was used to hold the spray material. To prevent contamination between chemicals, a number of containers were filled in advance with the various spray solutions. A container of diesel oil was used for flushing out the spraying wand and hose before switching from one chemical to another. The spray wand has a pressure gauge at the base which enables the operator to check pressures at all times. The nozzle is swiveled to permit adjustment to any angle, and disks can be interchanged to provide any size opening and spray pattern.

FIG. 3. First-year regrowth from breast-height applications of 2,4-D at 8 pounds AHG in diesel oil.

The spraying done in October 1954 was by means of an ordinary garden-type cylinder-tank sprayer but with a pressure gauge attached to the spraying wand to enable checking pressures. While pressures were approximately the same as used in other tests, this equipment did not permit the precision control possible with the experimental-plot sprayer. There was also a greater possibility of contamination between the 2,4-D and 2,4,5-T when using the garden sprayer.

A propane torch was used in some of the May 1954 tests. This unit uses propane gas in liquid form under pressure in the cylinder. The vaporization and combustion of the gas when released from the cylinder produces a hot, blow-torch-like flame about a foot long. Heat was applied for about 5 to 8 seconds until the bark began to char. A band approximately 6 inches wide at the base of each of the main stems was scorched. Some difficulty was experienced in getting an effective treatment because of the interference of other stems and because the short flame made it difficult to reach some parts of the clump conveniently. Danger to workers and the possibility of setting fire in the woods also limit the practicability of using fire.

The April 1955 tests included as one treatment scorching of a band about 1 foot wide on all the main stems at breast height. A pneumatic flame thrower commonly used by foresters for burning out fire-control lines, slash disposal, and other purposes was used. This equipment uses diesel oil under pressure which, when released, ignites and deposits flaming oil on the stems to be treated. The operator stood about 6 feet from the stems being treated.

While treatment by the flame thrower was found to be more convenient than by the propane torch, the same fire hazard exists.

*Methods of Application.*—Separate tests were conducted on May 18 and 19, 1954; October 26, 1954; and April 26, 1955. These tests will be referred to as tests A, B, and C

FIG. 4. Experimental pressure-tank sprayer.

respectively. All testing was done on the same area and where the environmental conditions were reasonably uniform. However, the three tests are not exact replications and are not considered as such in the analysis of the results. The various treatments involved in the three tests are described separately.

Treatments in test A were applied on May 18 and 19, 1954, during the early bud-swelling stage. Eighty-five clumps of mountain maple were included in the study. Two kinds of herbicides, the butoxy ethanol esters of 2,4-D and 2,4,5-T, were tried. These were used at concentrations of 4, 8, and 12 pounds AHG (acid equivalent in 100 gallons of diesel oil). Diesel oil alone and scorching by a propane torch were also used. Each treatment was applied to 5 clumps and applications were made either at the base or at breast height (4½ feet), except that scorching was done at the base only. Before treatment the number of stems in each clump was tallied by the following height classes: up to 3 feet, 3 to 7 feet, and over 7 feet. All dead stems were tallied and removed before treatment. Estimates of the top kill were made during the summer of 1954 and a final stem count was made on July 6, 1955. Regrowth was determined by counting the number of suckers and sprouts originating from the roots, root collars, and the stems of each clump and by computing the total lineal length. These counts were made in late October in 1954 and 1955.

Treatments in test B were applied on October 26, 1954, during the early dormant stage. The late-fall test was made to get as early regrowth as possible the following spring. Thirty-five clumps were used, and only breast-height treatments were tried. Concentrations of 4 and 8 pounds AHG were used. One treatment was made with diesel oil alone. Another treatment in which the stems were cut off with an axe at the ground line was also tried. Regrowth was determined on October 28, 1955, in the manner previously described.

Treatments in test C were applied on April 26, 1955, during the early bud-swelling stage which occurred earlier than in test A. Prior to spraying, all mountain maple clumps were classified into clump-size classes. Clumps

were stratified by these classes based on the number of stems over 3 feet in height. Stems less than 3 feet tall were considered to have less potential influence on the amount of regrowth than the larger stems. The smaller stems were also largely missed by the breast-height spray treatments. Therefore, the clump size was based on the number of stems over 3 feet tall. After stratification into clump-size classes, the 5 treatments were assigned by selecting at random two clumps in each of the 5 classes. The number of stems in each class was 2-4, 5-7, 8-10, 11-13, and 14-16 stems. Fifty numbered clumps were used and 2,4-D was applied at breast height using concentrations of 8, 12, and 16 pounds AHG in diesel oil. A flame thrower was also used in the test.

## DISCUSSION OF RESULTS

The treatments were evaluated on the basis of the amount of regrowth as determined by the number of stems and by the total lineal feet of stems. In addition, the percentage of the treated stems that were top killed was determined, since this was presumably related to the extent of regrowth. Observations were also made on the extent to which deer browsed on the regrowth.

Data in all 3 tests were subjected to an analysis of variance to evaluate the extent to which differences might be meaningful. In tests A and B it was necessary to apply an analysis of covariance to correct as much as possible the variations in the sizes of the clumps used. In the treatments applied in test C a simple analysis of variance was possible, as the clumps were stratified into size classes and a similar range of clump sizes was included in each treatment.

*Comparison of Results from 2,4-D and 2,4,5-T.*—For test A (May 1954) applications at early bud-burst time of both 2,4-D and 2,4,5-T (4, 8, and 12 pounds AHG) at breast height showed that 2,4-D was generally more effective in inducing regrowth (Fig. 5). The superiority of 2,4-D over 2,4,5-T was significant at the 5 per cent level when the analysis included all three concentrations. This was true on the basis of the number of stems of regrowth and on the basis of lineal feet of regrowth. The difference was greatest at 12 pounds AHG.

Common experience with these two herbicides in killing brush along roadsides and other places where a kill of roots and prevention of regrowth is the objective, indicates that 2,4,5-T is more effective in this respect for most species of maples. It would seem likely, therefore, that 2,4-D would be preferable where a top kill is needed but where regrowth from the roots and root collar is desired. Whether this reflects a difference in the degree to which these two herbicides translocate within the stem tissues or whether it results from greater toxicity of the 2,4,5-T cannot be determined from these tests.

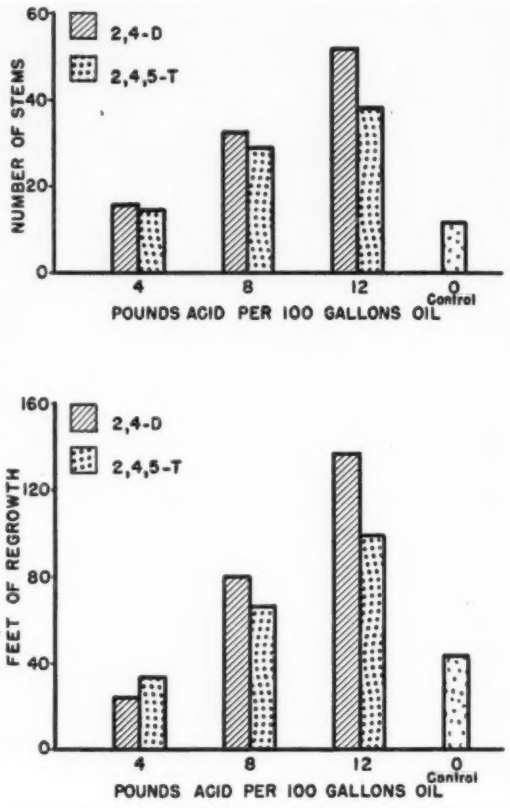



FIG. 5. Comparison of 2,4-D and 2,4,5-T applied at breast height.

*Comparison of Basal and Breast-height Treatments.*—The treatments in which the herbicides were applied at breast height resulted in generally greater stimulation of regrowth as compared with applications to the basal portions of the stems (Fig. 6). The breast-height applications were significantly

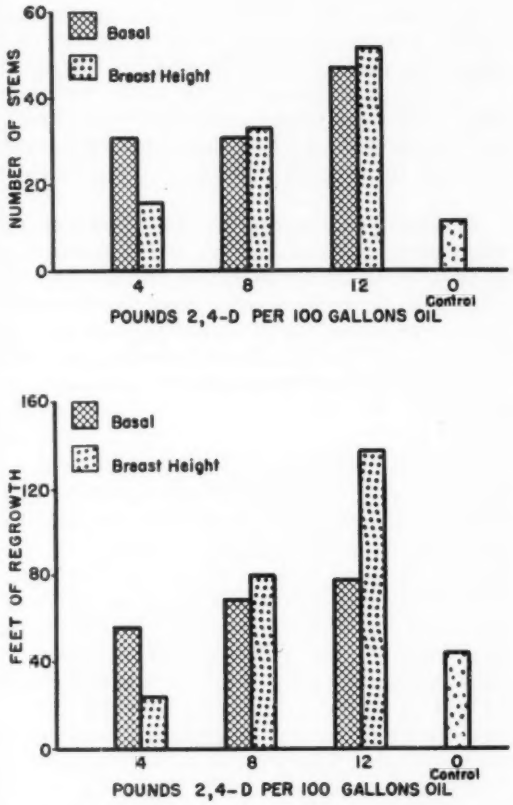



FIG. 6. Comparison of basal and breast-height applications of herbicides.

superior at the 5 per cent level when the analysis included all three concentrations. However, it should be noted that at the lowest concentrations tested (4 lbs. AHG) the basal applications of both 2,4-D and 2,4,5-T stimulated greater regrowth than did breast-height applications. The statistical significance of this apparent aberration was not tested, and its possible biological basis is not clear from these tests.

Mountain maple like many other brush species, produces stem sprouts and root suckers. These appear to arise largely in the lower stem and root collar areas which are directly involved in the basal applications of the herbicides. It seems very likely that these basal applications adversely affect the tissues giving rise to the regrowth of sprouts and suckers. Breast-height applications on the other hand do not directly contact this basal zone and the herbicide reaches these tissues only by translocation downward for several feet. The superior regrowth resulting from the breast-height applications is probably a result of their doing less injury to the meristematic tissues in the basal zone.

*Comparisons of Results from Different Concentrations of Herbicides.*—The number of stems and lineal feet of regrowth for both herbicides increased as the acid concentration was increased when applications were made at breast height (Fig. 7). The greater regrowth associated with the higher concentrations was found to be significant at the 1 per cent level. It seems likely that the greater effectiveness of the higher concentrations in obtaining a thorough top kill may result in a greater stimulating effect comparable to that obtained by cutting off the stems. It is also of interest that the per cent of top kill is greater when the higher concentrations are used.

For test B (October 1954) breast-height

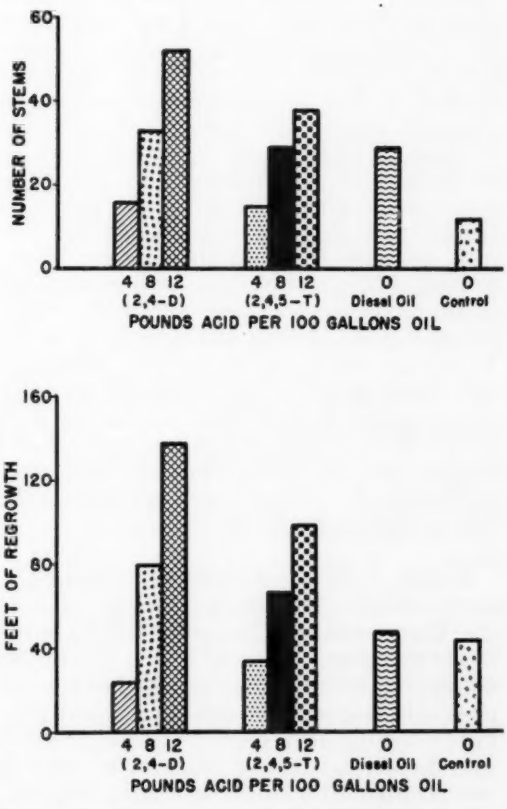



FIG. 7. Comparison of regrowth using different concentrations of herbicides.

applications of 2,4-D and 2,4,5-T were made in late October during the early dormant-bud stage. These applications were made at 4 and 8 pounds AHG. The average number of stems of regrowth per clump was 28 for the two herbicides, 14 for diesel oil, and 3 for the control. Average regrowth per clump expressed in lineal feet was 26 for the herbicide treatments, 32 for diesel oil, and 1 foot for the control. These data were analyzed statistically, but no significant differences were found. Apparently the experiment was not sensitive enough to detect the small differences. This may have been due in part at least to the smaller number of clumps sprayed, 10 for each acid strength in test B as compared with 20 for each acid strength in test A. Also in test B the results are based on only one growing season compared with two years for test A. However, it is of interest that generally less regrowth was obtained in this fall test as compared with the early spring tests.

For test C (April 1955) all applications were made at breast height and only 2,4-D was used during this early bud-burst stage. Concentrations of 8, 12, and 16 pounds AHG were tried. The average number of stems of regrowth per clump was 34 for all herbicide treatments, 10 for the flame thrower, and 4 for the control. Average regrowth per clump expressed in lineal feet was 44 for 2,4-D, 13 for the flame thrower, and 4 feet for the control. The difference in the amount of regrowth resulting from the herbicidal treatments as compared with either the flame thrower or the control was significant at the 1 per cent level. No significant difference was found between the three acid strengths (8, 12, and 16 pounds AHG). In this test as in test B the relatively few clumps treated and the fact that the results from only one growing season are available may account for the lack of sensitivity in the analysis.

*Results of the Tests Using Fire, Diesel Oil, and Cutting.*—Treatment with fire using either the propane torch applied basally or the flame thrower applied at breast height did not appear to stimulate regrowth to any appreciable degree. In no case were these treatments significantly superior to the controls. For the tests where herbicidal treatments were compared with the scorching methods, they were found to be significantly superior at the 1 per cent level.

Spraying with diesel oil alone generally resulted in much less regrowth than was obtained by cutting or herbicidal treatment.

Cutting with an axe in the early dormant stage produced about one-third more stems per clump than did 2,4-D and about two and one-half times more lineal feet of regrowth.

*Browsing on Regrowth.*—Observations of the extent of browsing by deer on the regrowth indicate no aversion to the treated clumps as compared to the controls. Actually there appeared to be some preference for browsing the herbicide-treated clumps. This was true for both one and two-year-old regrowth.

*Treatment Application Time and Cost.*—Since cutting mountain maple stems by axe and the use of 2,4-D sprays both seemed to produce desirable results in terms of regrowth for deer browse, it was felt that some idea of the relative costs of these two general methods would be of interest. In February and March 1956, a comparison of axe cutting and spraying as to labor time and costs of treatment was made. Five acres of mountain maple were cut by axe, and two acres were sprayed. The work was done when the snow was about 30 inches deep. On the 5 acres cut by axe the average number of stems per acre was 636, and on the 2 acres sprayed it averaged 591 stems. The treated stems ranged in size from 1 to 3 inches in diameter at breast height.

The herbicide was applied until runoff occurred from the bark. An average of 74 stems were treated per gallon of spray solution. On a basis of treating 1,000 stems, about 13.5 gallons were required. The amount of 2,4-D acid needed for this number of stems was 1.6 pounds, using a concentration of 12 pounds AHG.

Analysis of the data show that there is relatively little difference in the total costs of the treatments using axe cuttings and 2,4-D sprays (Table 1). It should be noted, however, that the present study was not designed to answer completely the question of which method is cheaper. Such decisions depend on the density of the species, ease of access, skill of the workers, and many other considerations related to the local situation. It should also be noted that a number of possibilities for reducing costs were not tested in this experiment. These include such things

TABLE 1. — TREATMENT TIME AND COST

| Treatment | No. Stems Treated per Hr. | Cost per 1,000 Stems | | | | Cost per Acre[2] |
|---|---|---|---|---|---|---|
| | | Labor[1] | Acid | Oil | Total | |
| Axe cutting | 157 | $8.00 | | | $8.00 | $4.77 |
| 2,4-D spray[3] | 217 | 5.75 | 1.00 | 1.86 | 8.61 | 5.18 |

[1] Based on a rate of $1.25 per hour.

[2] Based on an average of 600 stems per acre.

[3] Based on a cost of 60 cents per pound for 2,4-D ester and using a spray concentration of 12 lbs. AHG.

as cutting the stems by power equipment, using No. 2 diesel oil in place of the No. 1 grade, using oil-water emulsions rather than straight oil as a diluent, reducing the volume of spray to a minimum, and using specialized spray wands to cut down the time of application.

Although no attempt was made to test various ways of reducing treatment costs, effective treatments to induce growth were made for approximately $5.00 per acre. Where it is possible to cut the stems as cheaply as they can be sprayed, this method has the additional advantages of inducing better regrowth as well as making the cut tops immediately available for browsing by deer.

## SUMMARY AND CONCLUSIONS

In order to stimulate regrowth and to provide more browse, growth-hormone herbicides, fire, and diesel oil were used to top-kill mountain maple that had grown out of reach of deer in northeastern Minnesota. Applications were made at both the base of each clump and at breast height (4½ feet). The butoxy ethanol esters of 2,4-D and 2,4,5-T were used at acid concentrations of 4, 8, 12, and 16 pounds AHG (acid equivalent per 100 gallons of diesel oil). The use of fire included tests with a propane torch and a pneumatic flame thrower. Some tests were also made using an axe to cut down the stems. The herbicide and diesel oil sprays were applied with a pressure tank-type sprayer designed for experimental use and with an ordinary garden-type cylinder-tank sprayer. The spray was applied until runoff from the bark occurred. Separate tests were made on May 18 and 19, 1954; October 26, 1954; and April 26, 1955. The spring treatments were made at early bud-burst time and the fall treatment was made at the early dormant stage. The study included 170 test clumps.

Applications at early bud-burst time (4, 8, and 12 pounds AHG) showed that 2,4-D was generally more effective than 2,4,5-T in inducing regrowth for breast-height treatments. The superiority of 2,4-D was significant at the 5 per cent level for all three acid concentrations as a unit, and the difference was greatest at 12 pounds AHG. Breast-height applications resulted in generally greater stimulation of regrowth as compared with basal treatments. When the acid concentrations as a unit were considered, the superiority was significant at the 5 per cent level. As the acid concentration was increased, the number of stems and the lineal feet of regrowth also increased when the applications were made at breast height. The greater regrowth associated with the higher concentrations was found to be significant at the 1 per cent level. Tests with fire did not stimulate regrowth to any appreciable degree. However, where herbicidal treatments were compared with fire, the herbicides were significantly superior at the 1 per cent level. Diesel oil sprays alone generally produced less regrowth than was obtained by cutting or herbicidal treatment. Cutting with an axe produced the most regrowth.

Treatment application time and cost information for breast-height spraying of 2,4-D and cutting show that winter applications of the herbicide can be made faster than the stems can be cut down with an axe. However, the cost of the acid and the diesel oil diluent offset the gains made in treatment time. By either method the cost was approximately $5.00 per acre. Cutting also produced much more regrowth and the tops could be browsed by deer. Deer browsed on both one and two-year-old stems of regrowth, and even some preference was shown for the herbicide-treated clumps.

## LITERATURE CITED

HANSEN, H. L. AND C. E. AHLGREN. 1950. Effects of various foliage sprays on mountain maple (*Acer spicatum*) at the Quetico-Superior Wilderness Research Center. Res. Rept. Seventh Ann. N. Cent. Weed Cont. Conf. p. 240.

KREFTING, LAURITS W. 1941. Methods of increasing deer browse. J. Wildl. Mgmt., 5:95-102.

———. 1953. Effect of cutting mountain maple on the production of deer browse. Minn. For. Notes, No. 21.

ROE, EUGENE I. 1953. Resprouting of mountain maple after basal spraying with 2,4,5-T. Res. Rept. Tenth Ann. N. Cent. Weed Cont. Conf. pp. 73-74.

Received for publication April 12, 1956.

# WATERFOWL PRODUCTION DURING WET AND DRY YEARS IN NORTH-CENTRAL COLORADO[1]

*Lee E. Yeager and Harold M. Swope*

Colorado Cooperative Wildlife Research Unit, Fort Collins, Colorado; and Colorado Game and Fish Department, Fort Collins, Colorado

High, but stable, water levels generally are considered favorable to waterfowl production. Such conditions occur most frequently during wet periods, when precipitation is maximum, resulting in the filling and relative maintenance of levels in land depressions.

During the period of 1947-1955, precipitation reached annual highs and lows of wide diversity in north-central Colorado, as it did over much of the high-plains region. As a result, water levels here were high through 1949 and reached near-record lows in 1954 and 1955.

The junior author, working under the auspices of the Colorado Cooperative Wildlife Research Unit, completed in 1949 an evaluation of waterfowl-nesting areas and duck production on representative marshes, ponds, and lakes and on a main stream in north-central Colorado (Swope, 1950). The same sample was re-evaluated, with the same objectives, in 1955. Grieb, *et al.* (1954) conducted repeated and extensive waterfowl investigations in the general region. This paper, therefore, is primarily concerned with a comparison, on a local basis, of waterfowl production during two extremes in water level; and secondarily, it considers the differences in production as indicated by selective vs. representative samples applicable to the irrigated-land type.

## Types of Nesting Cover

In north-central Colorado, irrigated agriculture is the principal land use. Water supplies are almost exclusively delivered here by gravity flow, and numerous ponds, reservoirs, and canals, all directly or indirectly connected with the region's principal waterway, the Cache la Poudre River, become a part of the water system. These water types are identified as follows:

*Marsh*—shallow water, often not more than a foot deep, with typical marsh vegetation (*Typha, Scirpus, Carex, Salix,* etc.) growing in the water and around marsh margins. The filling of shallow depressions during a series of wet years, seepage from canals, and drainage into sloughs, account for marshes in the study locality. Seepage marshes generally are the most permanent.

*Pond*—depression, sometimes created by a low dam, less than 50 acres at high-water level, and deep enough to hold water except during the driest years.

*Lake* (reservoir)—impoundment larger than 50 acres and deep enough to hold water at all times, although levels during drought periods may become very low.

*Stream*—Cache la Poudre River only, the main water-carrying artery in north-central Colorado, with flood-stage flow of about 3,000 second-feet. Four sections, each about one-half mile long, involving both grazed and ungrazed conditions, and both wooded and open area, were selected as samples. Sections were located about four miles apart.

*Ditch*—Irrigation ditches, similar to the Cache la Poudre River as to the annual water cycle, were not sampled for waterfowl production in this survey. Ditches are less subject to flooding than the river, especially during wet years, but mortality to nests due to agricultural operations is greater. Net production per mile is roughly comparable to that observed on the river (Grieb, 1951).

## Precipitation and Water Levels

A direct comparison of precipitation and runoff in the Fort Collins region during years of relatively heavy (1947-1949) and relatively light (1953-1955) flow is given in Table 1. A clearer understanding of water build-up and depletion is attained in this comparison by including data for the two years next preceding 1949 and 1955, and by excluding precipitation during the last six months of these two years.

Nearly all of the land involved in the 24

[1]The Colorado A. and M. College, the Colorado Game and Fish Department, the Wildlife Management Institute and the U.S. Fish and Wildlife Service, cooperating.

TABLE 1. – PRECIPITATION AND RUNOFF, WET (1947-1949) vs. DRY (1953-1955) YEARS, NORTH-CENTRAL COLORADO

| Year | Precipitation, Inches[1] | Annual Runoff, Acre-feet[2] | |
|---|---|---|---|
| | | Natural | Natural plus Diversion |
| 1947 | 17.95 | 273,000 | 315,000 |
| 1948 | 10.45 | 195,000 | 225,000 |
| 1949[3] | 13.22 | 306,000 | 337,000 |
| Average, 2.5 yrs. | 16.65 | 258,000 | 292,333 |
| 1953 | 11.42 | 127,000 | 163,000 |
| 1954 | 8.01 | 113,000 | 127,000 |
| 1955[3] | 6.58 | 125,000[4] | 140,000[4] |
| Average, 2.5 yrs. | 10.40 | 121,667 | 143,999 |

[1] Weather Station, Agricultural Experiment Station, Colorado A. and M. College, Fort Collins, Bulletin 402-A, June, 1948, and cumulative records. Mean precipitation, 1887-1947, 60-year average–14.71 inches.

[2] Based on stream-flow measurements by the State Engineer of Colorado and U.S. Geological Survey, Department of the Interior. Water year, October through September.

[3] January through June, inclusive; last 6 months of year omitted.

[4] Estimated.

study areas (Table 2) is subject to irrigation farming, or the servicing of such farming, where alfalfa, sugar beets, corn, and small grains are the principal crops. The storage system in use is capable of holding a surplus of water. As a result, levels are built up during periods of heavy runoff, and the accumulated water is used during years of drought. Thus, in 1948, virtually every reservoir, pond, and marsh in north-central Colorado was brimming full, and the river in flood state, during the waterfowl-breeding period. Nesting conditions, except along the river, were considered good to excellent.

In 1955, very low water levels prevailed. Many marshes and shallow ponds were dry or nearly so; and naked shore lines, sometimes as much as 200 yards wide, characterized reservoirs that still held water. The river bottom, on the other hand, remained unflooded throughout the nesting season. More precise descriptions of the 24 nesting areas covered are given in Table 2.

## PRODUCTION

Comparison of waterfowl production during the two years is given by areas in Table 2 and in summary in Table 3. The total observed production, while somewhat less, is nevertheless proportional to habitat loss. Obviously, production per acre showed less variation due to concentration of the admittedly smaller breeding population on nesting ground reduced in area by 62 per cent.

Each of the 20 marshes, ponds, and lakes held one or more broods under conditions of high water level; only three of these samples produced young ducks in 1955 when very low water stages prevailed. Conversely, the river habitat, considered by far the least desirable nesting range in 1949—primarily because of flooding—showed increased production in 1955.

Because of the certainty of water each year, the river type shows a smaller degree of fluctuation in nesting-ground suitability than do marshes, ponds, and reservoirs. Grieb (1951) found much the same condition along irrigation ditches, which likewise annually received water from irrigation storage, regardless of precipitation.

During examination of the various study areas in 1955, it was evident that land use had changed adversely for waterfowl production since 1949. Many, and perhaps most, such changes resulted from lowered water levels and consequent drying out of wetland soils. Thus, land around marshes and ponds, too wet for agricultural crops during years of heavy runoff, became available for wheat, barley, corn, and forage crops. Other erstwhile wetlands were pastured. In both instances the high prices for grain and livestock insured nearly maximum use for agricultural purposes, resulting in material reduction in habitat suitable for waterfowl nesting and production.

Still other effects accrued from excessive drought. Some of the low areas were drained; others were filled in land-leveling operations. Water levels low enough to permit earth moving on a large scale induced these changes. The amount of low land—shallow marsh in 1949—drained or leveled in the Fort Collins area is appreciable. The area so affected is permanently lost for waterfowl use.

## LOCAL VS. REGIONAL PRODUCTION

It cannot be overemphasized that the investigation considered thus far is local in nature and primarily concerned with the nesting habitats most seriously affected by drought conditions. It is evident, in the light of other studies (Grieb, 1955; Grieb, *et al.*, 1954), that the region-wide results of

TABLE 2. — COMPARISON OF WATERFOWL NESTING AREAS AND PRODUCTION, WET (1949) vs. DRY (1955) YEAR, NORTH-CENTRAL COLORADO

| Area Type | Area No. | Wet, 1949 Acres | Wet, 1949 No. of Young | Dry, 1955 Acres | Dry, 1955 No. of Young | Remarks (condition in 1955 as compared to 1949) |
|---|---|---|---|---|---|---|
| Marshes | 1 | 30 | 6 | 25 | 0 | *Typha* replaced by *Carex* |
| | 2 | 40 | 7 | 20 | 8 | Seepage and vegetation much reduced |
| | 3 | 40 | 9 | 0 | 0 | Dried up, little vegetation |
| | 4 | 55 | 7 | 20 | 6 | Slough being filled with soil |
| | 5 | 35 | 4 | 0 | 0 | Dried up, heavily grazed |
| | 6 | 100 | 8 | 0 | 0 | Completely dry, heavily grazed |
| | 7 | 30 | 9 | 10 | 0 | Vegetation reduced 85 per cent |
| | Totals | 330 | 50 | 75 | 14 | |
| Ponds | 8 | 25 | 11 | 10 | 11 | Dried up in 1954, flooded in 1955 |
| | 9 | 20 | 6 | 0 | 0 | Dried up, bottom bare |
| | 10 | 30 | 6 | 0 | 0 | Dried up and pastured |
| | 11 | 40 | 6 | 20 | 0 | Fair, but reduced, vegetation |
| | 12 | 35 | 7 | 20 | 0 | Nearly all nesting cover grazed off |
| | 13 | 15 | 6 | 0 | 0 | Dried up, bottom bare |
| | 14 | 35 | 6 | 0 | 0 | Dried up, bottom bare |
| | 15 | 45 | 6 | 5 | 0 | All vegetation grazed off |
| | Totals | 245 | 54 | 55 | 11 | |
| Lakes | 16 | 70 | 5 | 35 | 0 | 100 yds. between water and vegetation |
| | 17 | 105 | 5 | 25 | 0 | Nearly dry in 1954, suddenly flooded in 1955 |
| | 18 | 60 | 7 | 10 | 0 | Dried up, bottom bare |
| | 19 | 135 | 9 | 10 | 0 | 50 to 200 yds. between water and vegetation |
| | 20 | 115 | 6 | 40 | 0 | Little water left |
| | Totals | 485 | 32 | 120 | 0 | |
| Stream Sections[1] | 21 | 50 | 0 | 50 | 7 | Not flooded in 1955, partly grazed |
| | 22 | 60 | 0 | 60 | 0 | Not flooded in 1955, heavily grazed |
| | 23 | 80 | 0 | 80 | 3 | Not flooded in 1955, river dredged |
| | 24 | 60 | 5 | 60 | 0 | Not flooded in 1955, partly grazed |
| | Totals | 250 | 5 | 250 | 10 | |

[1] Each section approximately one-half mile in length and about 4 miles apart.

drought, where *all* habitat types are proportionately sampled and evaluated, did not indicate equally low levels in duck production.

Extensive studies executed since 1950, involving some of the areas listed in Table 2 (Grieb 1951, 1955), are available for comparison. Unfortunately, they do not extend back to 1949, which appears to have been the year of peak duck production in north-central Colorado. The estimated number of breeding pairs, broods, and young for the 343-square-mile area of the Cache la Poudre

TABLE 3. — CHANGE IN WATERFOWL NESTING AREA AND PRODUCTION, WET (1949) vs. DRY (1955) YEAR, NORTH-CENTRAL COLORADO

| Type | Wet, 1949 Acres | Wet, 1949 Production | Wet, 1949 Acres per Duck | Dry, 1955 Acres | Dry, 1955 Production | Dry, 1955 Acres per Duck | Change in 1955, per cent[1] Area | Change in 1955, per cent[1] Production |
|---|---|---|---|---|---|---|---|---|
| Marshes | 330 | 50 | 6.6 | 75 | 14 | 5.4 | –77 | –72 |
| Ponds | 245 | 54 | 4.5 | 55 | 11 | 5.0 | –82 | –80 |
| Lakes | 485 | 32 | 15.1 | 120 | 0 | —[2] | –75 | –100 |
| Stream | 250 | 5 | 50.0 | 250 | 10 | 25.0 | 0 | +100 |
| Totals, avg. | 1,310 | 141 | 9.3 | 500 | 35 | 14.3 | –61.8 | –75 |

[1] Production per acre reduced only 34.5 per cent in 1955 due to concentration of breeding ducks on smaller area.
[2] Figure indeterminate since no production was recorded.

Valley, years of more or less average water levels vs. the drought years of 1954 and 1955 (Grieb, 1955:200 and unpublished), are given in Table 4.

TABLE 4. — WATERFOWL BREEDING POPULATION AND PRODUCTION, CACHE LA POUDRE VALLEY, COLORADO, 1952-1955

| Population | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|
| Breeding pairs[1] | 1,029 | 1,619 | 1,320 | 1,164 |
| Broods | 781 | 800 | 877 | 514 |
| Young | 4,851 | 4,821 | 4,867 | 2,698 |

[1] Mallard (*Anas platyrhynchos*), 78 per cent; blue-winged teal (*A. discors*), 15 per cent; gadwall (*A. strepera*), 4 per cent; cinnamon teal (*A. cyanoptera*), 1 per cent; miscellaneous, 2 per cent. This approximate ratio in species was observed by Swope (1950).

The data in Table 4 indicate great comparability in production (based on young), 1952 through 1954. The decline, percentagewise, in 1955 as compared with 1952, was 44.4. On a local basis (Table 3), the decline in 1955, as compared to 1949, was 75 per cent. This differential may well represent the variance between selective and randomized sampling. Certainly, the decrease of 44.4 per cent is more applicable to north-central Colorado as a whole, and is, therefore, a more valid figure.

Weather records show the year 1954 to be exceedingly dry in eastern Colorado. Yet, as reported by Grieb (*op. cit.*), waterfowl production on irrigated land in this region showed no decline below the preceding two years. This may be accounted for by the combination of stable, nonflooded streams and ditches in 1955, and by the cumulative effects of continued drought on all other nesting range. Thus, water levels, already low except in streams and ditches, became intolerably reduced in 1955, forcing nesting ducks to other regions after watered cover had been filled.

These indications suggest that homogeneity in waterfowl nesting ground, however desirable under favorable conditions, may be the basis of disaster during years of climatic adversity, most often featured (for waterfowl) by abnormally high or low water. Thus, nearly level marshes on the Canadian prairies may flood or dry up, either sequence affecting production over a large area. Conversely, variable nesting range such as illustrated by the marshes, ponds, lakes, and streams characteristic of irrigated land in Colorado, is never subject to complete inundation or water evaporation. Thus, for nesting purposes, dried-up marsh on such range is compensated for in drought years by greater use of streams and ditches; and during years of peak water level, the shores of marsh and lakes, never under water, offer acceptable nesting grounds. Then bottomlands and other flooded covers appear to be avoided by nesting birds.

This type of compensation was pointed out by Grieb, *et al.* (1954), in reporting their studies of waterfowl production in the Cache la Poudre and South Platte valleys, in the following pertinent statement:

"Comparison of 1953 production with that of past years . . . shows very little difference between years. . . . Uniformity . . . in total production during the 4-year period is striking, and probably significant. . . . Analysis of the data indicates that there is a change in the nesting pattern by habitat types from year to year which seems to correspond to the difference in seasons."

It should, of course, be kept in mind that the results reported here, and by Grieb, *et. al.* (1954), accrued from a breeding population predominantly mallard, perhaps the most versatile of American species as regards habitat and nesting grounds. Comparable results almost certainly would not have been obtained from species more exacting as to nesting range, such as most of the diving ducks.

## SUMMARY

Waterfowl production was studied on 24 small marshes, ponds, lakes, and stream sections in north-central Colorado during the peak of the precipitation cycle (1949) and during near-record drought (1955). Suitable nesting habitat showed a reduction of 61.8 per cent (1,310 acres vs. 500 acres) and production a decline of 75 per cent (141 young vs. 35 young). Much of the shallow marsh type was drained prior to 1955 and is now permanently lost to waterfowl production. Mallards constituted about 75 per cent of the breeding population. In wet years, production lost to flooding along streams appears to be compensated for by relatively high nesting success around marshes and ponds; and during years of low rainfall and runoff the versatile mallard finds fair to good nesting ground in unflooded river bottoms.

Waterfowl production for the Cache la Poudre Valley as a whole—about 343 square miles of river bottom and irrigated farmland—was thus only 44.4, rather than 75, per cent lower in 1955 than during years when average water levels prevailed.

### LITERATURE CITED

GRIEB, JACK R. 1951. The evaluation of waterfowl production in north-central Colorado. Colorado A and M College, Fort Collins. Master's thesis, 107 pp.

——. 1955. Waterfowl breeding ground survey—Colorado, 1954. *In* Waterfowl populations and breeding conditions—summer 1954. U.S. Dept. Int., Fish and Wildl. Serv. *and* Canad. Dept. No. Affairs and Nat. Res., Wildl. Service, Spec. Sci. Rept.—Wildl. No. 27, pp.197-201.

——., HAROLD M. BOEKER, JOHN R. TESTER, ERWIN L. BOEKER, AND LADD G. FRARY. 1954. Waterfowl breeding ground survey in Colorado, 1953. *Ibid.*, Wildl. No. 25, pp.173-182.

SWOPE, HAROLD M. 1950. Waterfowl production and habitat evaluation on selected sample areas near Fort Collins, Colorado. Colorado A and M College, Fort Collins. Master's thesis, 76 pp.

Received for publication December 12, 1955.

## OBITUARIES

### KENNETH A. REID

### 1895-1956

The death of Kenneth A. Reid, at 61, in the Presbyterian Hospital, Pittsburgh, Pennsylvania, on May 21, 1956, turned the final page on one of the most notable careers in North America's conservation history.

And with his passing another of that small select group upon whom the Wildlife Society has seen fit to bestow its special recognition for outstanding service in the conservation field has slipped from our midst. Ken Reid was voted the Society's Honorary Membership in 1944.

It was this biographer's good fortune to become acquainted with Ken about the time when he organized the Connellsville and Uniontown, Pennsylvania, chapters of the Izaak Walton League of America, shortly after he returned to his native Connellsville home in 1927. There, as a boy, he had learned to fish and enjoy the outdoors on the estate where he lived at his death.

The determined zeal with which he espoused the cause of conservation, and his selfless dedication thereto, at once stamped him as a man who would fight to the last breath for his ideals. He repeatedly demonstrated this sterling quality during the intervening years.

Ken Reid, a sportsman in the true sense of the word, a fly fisherman, and a hunter of wide experience, was a fighting crusader who believed that the natural resources of the nation should be preserved for the wise use and enjoyment of posterity; that the continent's outstanding scenic beauty spots and the wild, unspoiled wilderness areas should not be sacrificed on the altar of commercialism; and that the soils, clean waters, green forests, and wildlife belong to unborn generations as much as they do to us.

One of his first conservation victories was the saving of Blackwater Falls from destruction, one of the great beauty spots of that region on the Blackwater River in West Virginia. Single-handedly he battled a big power company that planned to destroy the falls for a hydro-electric project. He fought the project through the courts, and won. Today these falls are the center of attraction in the Blackwater River State Park of West Virginia. The president of the power company later acknowledged that Reid's stand had actually saved his company millions of dollars because it was proved that power in that instance could be produced cheaper by coal.

By appointment of Gifford Pinchot, then governor of Pennsylvania, Ken became a member of the Pennsylvania Fish Commission in 1932, and left an indelible impress on the fisheries program of his native state. It was at his instance that certain waters were set aside exclusively for the fly fisherman, a program that was later expanded and widely emulated in other parts of the country.

In 1938 he assumed national leadership of the Izaak Walton League, becoming its executive director, with offices in Chicago. The organization was in difficult financial straits at the time. He used some of his own funds to preserve the League's existence. He set high goals for the League, and campaigned throughout the United States for his ideals. He frequently appeared before congressional committees in behalf of conservation projects, or to oppose undesirable legislation.

In his capacity as executive of the Izaak Walton League, Ken Reid spearheaded a nation-wide campaign for the establishment of a federal water-pollution-control agency to help the states clean up the polluted waters of the nation. The proposal was adopted in modified form by the 80th Congress in 1948 (Pub. Law 845).

Reid also carried to successful conclusion a campaign to raise funds for the purchase of private lands that endangered the Quetico-Superior Wilderness

Area (one of the League's original projects), which lands were later turned over to the federal government at a loss. But the League had accomplished its objective to set a national pattern, and at the same time to stop commercial encroachment upon this vast lakeland wilderness country.

It is reliably reported that Harold Ickes once offered him a post as assistant secretary of the Interior Department, but he refused on the ground that he could do more good in the conservation field as head of the Waltonians.

In 1949 Reid suffered a cerebral hemorrhage, which compelled him to relinquish his post with the Izaak Walton League. Upon recovery he became director of natural resources at Whitney Park, Sabattis, New York, where he did considerable research on the effect of water temperatures and trash fish in the propagation and rearing of trout in the wild. The results of that work have been assembled for publication in book form. At Sabattis he also successfully reared landlocked salmon in a lake, the first time this was known to have occurred in the Empire State.

Ken Reid was a photographer of considerable ability, and much of his activities were preserved on film. Upon returning to his ancestral Connellsville home a few months prior to his death, he completed an elaborate workshop and darkroom to enjoy his photographic hobby.

Ken graduated from Yale in 1917, then served as a flier in World War I. At the conclusion of that fracas he settled in Fort Worth, Texas, where he engaged in the automobile accessory business. On October 1, 1920, he married Henry Ruth Lassiter of that place. She and her two daughters survive.

Listed in "Who's Who in America," among Ken Reid's associations in addition to the Izaak Walton League are the Society of American Foresters; Natural Resources Council; Wildlife Society; American Fisheries Society; former editor of the Fishing Department, *National Sportsman*; Phi Gamma Delta; Yale Club, New York; Cosmos Club of Washington; Anglers Club of New York; and the University Club of Chicago.

Ken Reid was truly an outstanding conservationist and all-around sportsman, to whom unborn generations will be everlastingly indebted.—SETH GORDON

# REVIEWS

*Pheasants in North America.* Edited by Durward L. Allen. The Stackpole Company, Harrisburg, Penn. and the Wildlife Management Institute, Washington, D.C. xviii+490 pp., illus. 1956. $7.50.

This book is a sequel to W. L. McAtee's *The Ring-necked Pheasant and Its Management in North America* (The American Wildlife Inst., 1945). It follows somewhat the same pattern of the earlier book in that Chapters 2 through 8 treat geographical regions of the continent and are authored by workers in or having experience with pheasants in these regions. In general, the book summarizes progress in pheasant research and management up to about 1951. The authors, different by design from those of McAtee's earlier book, are biologists of federal, state, and private institutions. The book is liberally illustrated by 82 excellent plates, a colored frontispiece that is a reproduction of a painting by Bob Hines, and by handsome chapter heads that are pen-and-ink sketches of the type for which Hines is well known.

Chapter 1 by Fred H. Dale is a good, general summary of the existing knowledge on the life history and biology of the species. Chapters 2 through 8 follow pretty much a common pattern: each contains a history of establishment for the region; a description of the present distribution of populations along with descriptions of habitat and consideration of limiting factors; information on fluctuations and possible causes; in some cases, a synthesis of some principles of population dynamics; and finally a discussion of management problems. Chapter 2 by J. Burton Lauckhart and John W. McKean, an especially well-written chapter, treats the northwestern states and British Columbia. Chapter 3 by Chester M. Hart, Ben Glading, and Harold T. Harper is another very good piece of writing that deals entirely with California. Of particular interest is their account of the conditions under which pheasants survive in the Imperial and Mexicali valleys. Chapter 4 by Lee E. Yeager, Jessop B. Low, and Harry J. Figge covers the Intermountain and southwestern region. This chapter provides some interesting information on the relationships of pheasant distribution to irrigation, although the writing is at times slightly repetitious and lacking in clarity. Chapter 5 covers the "Plains and Prairies" and is written by James W. Kimball, Edward L. Kozicky, and Bernard A. Nelson. It contains a great deal of information that will be of value to pheasant technicians and includes an especially interesting account of the east-west shifts in population distribution during the fluctuations of the 1940's. One unfortunate fault with this chapter is the handling of the section on "Pheasant Biology." In my opinion the huge mass of population data painstakingly accumulated by technicians in these states, especially South Dakota, is a tremendously valuable contribution to our knowledge of pheasant population dynamics. These data have been summarized in progress reports, but with one or two exceptions they have not yet been subjected to the critical analysis needed to synthesize a set of principles from them. Time and space probably did not permit such a thorough analysis in this

chapter; and such complex statistics as average brood sizes, per cent of hens with young, and cock age ratios are only given cursory and superficial treatment in some 14 pages. As a result, the analyses are incomplete; and vague, tentative, and in some cases, I think, incorrect conclusions are reached.

Chapter 6 on the Lake States was written by Robert A. McCabe, Ralph A. MacMullan, and Eugene H. Dustman. This is the longest and most comprehensive chapter in the book. It is unfortunately marred by a serious lapse in editorial care: there are at least ten minor grammatical, typographical, or editorial errors. Figure 16 showing, among other things, the trend in average U.S. corn price does not indicate whether the price is in cents, dollars, or some unspecified index value. When the reader is first referred to Tables 45, 46, and 47 in the text, he is obliged to turn back 11, eight, and six pages respectively to find the tables. There is a mix-up in the text citation and numbering of Figures 19, 20, and 21. Credit lines are omitted or incorrect on at least two photographs, a reference cited in the text is not in the bibliography, and a publication is incorrectly quoted through what appears to be a typographical error. In spite of this, the chapter is generally good, although one wonders if the authors may not have been somewhat overzealous about the density of their pheasant populations when they state that "... the pheasant occupies about 65 per cent of the land area in the Lake States."

In the shortest, and yet perhaps most lucid and well-written chapter, Allen W. Stokes covers his important "laboratory" population study on Pelee Island. The last of the regional chapters, written by Allan T. Studholme and Dirck Benson, discusses the pheasant in New England and the Mid-Atlantic states. Of special interest are quantitative data describing the pheasant range in this region. The final chapter (No. 9), which sums up management prospects and research needs, is written by the editor in the excellent style for which he is so well known. There is a bibliography of 249 titles, and finally a detailed index of subjects and authors.

C. R. Gutermuth, in his introduction, asserts that the book "... will be of particular interest to students of wildlife, fish and game technicians and administrators, game breeders, and sportsmen." It does not seem likely that the book will find such wide interest. It is mainly a technical contribution and will be of primary value to University people, and to research men and game managers specifically concerned with pheasants. While it may be of value to an occasional administrator with a specific pheasant problem, it seems unlikely that it will be read thoroughly by most busy administrators. And although some authors appear to have attempted in varying degree to "slant" their writing toward the layman, the book is, in my opinion, largely beyond the ken of the average sportsman.

The editorial job leaves much to be desired. While it is not generally as bad as indicated for the Lake States chapter, one can find grammatical or editorial errors in every chapter as well as in the bibliography. The style of the table headings is not consistent—some are capitalized, some are not. Chapters 6 and 8 each have a paragraph that appears to be completely out of place and context, possibly due to misplacement when page proof was being made up from the galleys. Certain general touches could have been added that would have given the book greater unity and clarity. For example, each regional chapter has a population distribution map broken down in considerable detail by different density levels. However, at no point in the book is it definitely stated what season these map densities represent (despite the fact that spring and fall densities may vary by a factor of two or three, or that the hunting season may remove nearly half of the populations in some areas). While space probably did not permit elaboration, some readers will want to know the source of the data from which these detailed maps were compiled. There is no uniformity in citing winter sex ratios: some are expressed as cocks per 100 hens, others as hens per cock. Standard expression throughout would have contributed to unity. In some chapters, recovery rates on stocked cocks are cited without qualifying information on the ages of the birds at release, the type of area and hunting pressure in which the birds were released, or the means by which the bands were recovered. Without this qualifying information, such statistics are absolutely meaningless. Data cited in this book show that the method of obtaining the band recoveries (voluntary band return vs. personal contact of hunters on release areas) alone may cause the recovery rate to vary by factors of 3.7 (pp. 438-439), 8.9 (p. 354), and 13.9 (average of seven recovery rates from voluntary return and five from hunter contacts all on fall-released birds, pp. 76-77). In an era when the wildlife field is struggling to gain professional recognition, it is unfortunate that more careful editing was not given this most recent and definitive work on one of our most intensively studied species.

Some general impressions on the progress in our research and management thinking, as brought out by this book, seem worth recording. There is apparent in most chapters, in varying degree, a tendency to fit onto the pheasant certain hypotheses of population dynamics that tend to be somewhat stereotyped and often, I believe, oversimplified for this species. In some cases they are transferred directly from the Erringtonian principles on bob-white. They generally involve the concept of a "carrying capacity" or asymptote, usually assumed to be some relatively concrete and finite population level. In some cases the Erringtonian concept of an inverse relationship between spring populations and spring-fall gain in quail is inferred. An interesting commentary on how fragmentary and circumstantial are the data that are used to support these hypotheses is provided by contrasting the material given in Chapters 2 and

9. Lauckhart and McKean state (pp. 61-62) that pheasant numbers in the Northwest "... appear to be limited by winter carrying capacity .... Spring population counts ... show considerable stability in pheasant numbers over a period of years .... Fall, or hunting season, numbers fluctuate widely depending on reproductive success, while spring supplies nearly always are bound within the narrow limits of winter capacities." Offered in evidence of these statements are five years of prenesting-season censuses on five areas in Washington and Oregon, and estimates of the Washington pheasant kill for about the same five-year period. Scrutiny of the data shows that the average deviation of the kill from the five-year mean is 14.4 per cent. While the average deviation from the mean on two of the spring census areas is less than this (6.7 and 8.7 per cent), it is *greater* on the other three spring areas (15.2, 20.1, and 21.4 per cent). Furthermore, there is a suggestive correlation between annual variations in the kill and in the number of hunters. The hypothesis seems far from proven with the data provided.

In contrast, Allen holds (pp. 436-437, 459-461) that limitation is brought about in the *fall*. The pheasant is capable of producing far more birds than the fall habitat will support, and "... by a drastic culling process, a large, natural surplus is eliminated and the population reduced to a level determined largely by habitat conditions (which include weather) in the particular season .... One expression of carrying capacity in nearly all habitats will be the number of young birds that can be produced on an area in a favorable breeding season. A given number of hens will be required to achieve this maximum production, and hens over and above that number are likely to be largely ineffective .... We can assume that nearly every area in occupied range is supporting about all the pheasants possible under existing conditions—including, of course, such variables as seasonal weather." The data cited to support these contentions are from a thesis by William E. Green on a study area in northern Iowa. In three successive years (1936, 1937, and 1938), Green had spring populations of 18, 40, and 35 hens per section. In spite of this variation in breeding-population level, the fall populations in each year achieved roughly the same level—between 100 and 125 birds per section.

It is difficult to accept the hypothesis on these fragmentary data, particularly in view of the fact that later studies on identically the same area (Baskett, 1947, Ecol. Monog., 17:1-30; Kozicky and Hendrickson, 1951, Proc. Iowa Acad. Sci., 58:491-495) failed to show the same pattern. Furthermore, fall populations in northern Iowa during the period 1936-1938 were undergoing the upsurge characteristic of the Midwest at that time (Kozicky, Hendrickson, Homeyer and Speaker, 1952, Trans. N. Amer. Wildl. Conf., 17:293-305), and it seems unlikely that the stable situation found by Green on his area was characteristic of the range at large. It can be said that change, rather than spring or fall stability, has been the rule in Midwest pheasant populations in the past 20 years and probably longer.

The point I want to stress, however, is not the research technique of the persons involved. The proposal and testing of hypotheses is an accepted scientific procedure. How much evidence one demands before he accepts an hypothesis as established principle is entirely a matter of personal standards from the purely scientific point of view. Every investigator is at liberty to weigh the evidence and accept or reject the hypothesis. However, when some field of operation bases its policies on a science, it then behooves the investigator to proceed with caution. This is especially true in game management where we are entrusted with the wise use of public funds, and where our approach must be sound because of periodic lack of agreement that research is essential to the field. The important point to note is that both Lauckhart and McKean and Allen have advocated management policy on these unproven hypotheses. The Northwest authors hold that, because population control occurs in winter, it is sound to stock hens in spring and cocks in summer or fall. Allen, on the other hand, maintains that because control occurs in fall, any stocking of breeders or young is *unsound* because it is placing birds "... in environments that are stocked to capacity already .... In many areas it may well be that production by such breeders or survival of such young does not represent a gain. Some or all of them probably are there *in place of* (*sic*) individuals originating in the wild population that would have made the grade otherwise." Both Lauckhart and McKean and Allen condone the idea of shooting hens on the basis of their hypotheses.

In preresearch game management, policy was based on hypotheses—buck laws, predator control, stocking, etc. The objective of research in game management is not, in my opinion, the substitution of newer, more sophisticated hypotheses for old; but its role is to supply facts and careful, objective interpretations on which management can be based. We must learn to make sharper distinction between hypothesis and fact, or between hypothesis and firmly established principle in which cause-and-effect relationships have been worked out.

Much the same comments can be made about our pheasant habitat-management programs. We accept the axiom that game populations are dependent upon favorable environment, and that our best approach is to manipulate this environment to make it more favorable. We then set up hypotheses that what is needed is more cover. In some cases (viz. the Dakotas) this may be correct, but instead of beginning on a small, controlled, carefully evaluated scale to test the hypothesis, we proceed immediately to commit large portions of game-department budgets to nurseries and shotgun-pattern planting programs. Several of the chapter authors have mentioned the need for evaluation of habitat-manage-

ment programs, but most have not sufficiently emphasized the need for evaluation prior to making big commitments in such programs.

One cannot help but see parallels between this movement and stocking programs of 10 to 20 years back. Just as they used to speak with pride of the numbers of pheasants stocked, administrators today speak in glowing terms of how many hundreds of thousands of trees and shrubs are planted each year with scarcely a question of whether this is doing the job or is really what is needed. And with the growing skepticism among technicians over the success of these programs, I suspect that in a few years it will be just as fashionable to pooh-pooh them as it has been to condemn stocking during the past ten years. If anything, we will have less evidence of the contribution of this program than we presently have of the contribution of stocking. And just as with stocking, we will be able to question how many license fees it takes to put one bird in the bag through our present cover-planting programs.

My point is not that habitat management is not the proper approach, or that in some cases the cover-planting programs may not be doing the job. It is simply that we must base policy on fact and firmly established principle rather than on hypothesis, and it is the responsibility of sound, cautious, and critical research to make that distinction and to establish the principles. This is nothing new. It is the long-established relationship between research and operations in other fields—medicine, agriculture, industry.

While to this point I have been largely critical, it should not detract from the fact that this book is a valuable and important contribution. For the game manager or administrator who has pheasant problems, or for the student just starting out on a pheasant project, it is a ready reference and compilation of the knowledge up to about 1951. We need many more such books on each of our more important game species. It goes without saying that this book should be on the shelf of every wildlife library.

The pheasant researcher will find of great value the excellent habitat descriptions for the various regions, the information on population fluctuations, and other heretofore unpublished findings from theses and mimeographed reports. While viewing this continental pheasant panorama, he will once again be impressed by what a tremendously adaptable species this bird is, and what a variety of situations it thrives under. Finally, this book serves the important purpose of helping to widen the pheasant technicians' perspective and to aid in the exchange of ideas and approaches. This has been a crying need in pheasant research as the book's editor has ably discussed elsewhere (Allen, 1950, J. Wildl. Mgmt., 14:105-114). The editing of this book was undoubtedly a huge and thankless task. In doing it, Durward Allen has done a great service to the game-management field.—FREDERIC H. WAGNER.

## RECEIVED FOR REVIEW

*The flamingos: their life history and survival/With special reference to the American or West Indian flamingo* (PHOENICOPTERUS RUBER). By Robert Porter Allen. National Audubon Society. Research Report No. 5. 1956. xvi + 285pp. $3.95.

*The white-tailed deer in Wisconsin.* By Burton L. Dahlberg and Ralph C. Guettinger. Game Management Division, Wisconsin Conservation Department, Madison 1, Wisconsin, Technical Wildlife Bulletin No. 14. 1956. [One copy free per each individual request; additional copies $1.00 each postpaid.]

*Pelicans in the wilderness / A naturalist's odyssey in North America.* By F. Fraser Darling. Random House, Inc., New York, New York. 1956. 380pp. $5.00.

*Travels and traditions of waterfowl.* By H. Albert Hochbaum. The University of Minnesota Press, Minneapolis, Minnesota. 1956. xii + 301pp. $5.00.

*Complete book of the wild turkey.* By Roger M. Latham. The Stackpole Company, Harrisburg, Pennsylvania. 1956. xx + 265pp. $4.95.

*Nature's guardians / Your career in conservation.* By Harry Edward Neal. Julian Messner, Inc., New York, New York. 1956. 192pp. $3.50.

*The desert bighorn sheep of Arizona / A research and management study.* By John P. Russo. State of Arizona Game and Fish Department, Phoenix, Arizona. 1956. vi + 153pp.

*Der Waidgerechte Jäger.* By Hermann Schulze. Pub. Paul Parey, Hamburg and Berlin. 1955. 13th Edition. 132pp. 88 illustrations.

*The deer of North America / The white-tailed, mule and black-tailed deer, genus* ODOCOILEUS */ Their history and management.* By Walter P. Taylor (editor). The Stackpole Company, Harrisburg, Pennsylvania, and The Wildlife Management Institute, Washington, D.C. 1956. xx + 668pp. $12.50.

*Hunting the lawless.* By Hugh M. Worcester. American Wildlife Associates, 1229B University Avenue, Berkeley, California. 1955. 298pp. $5.00.

# BRIEFER ARTICLES

## A SIMPLE AUTOMATIC PHOTOGRAPHIC UNIT FOR WILDLIFE RESEARCH[1]

*Leslie W. Gysel and Earle M. Davis, Jr.*

Department of Fisheries and Wildlife, Michigan State University, East Lansing

A method for determining what animals were utilizing various seeds on the ground was needed during a forest-tree-seed study. Some data were obtained from baited live traps and direct observations of animals. A photographic flash unit with an automatic shutter-releasing device was then considered for taking pictures of the animals eating seed baits. A device of this kind had to be simple, inexpensive, and operable under all weather conditions. A review of the literature revealed relatively few descriptions of photographic devices of this type using modern synchronized flash equipment. Solenoids were used to release the shutter directly (Benter, 1934; Rozelle, 1954) or to release a spring (Karcher, 1938). Another type of device was an electromagnet which released a spring-driven bar (Wing, 1948). Mechanical releases consisting only of a spring (Shepard, 1953) or a weighted metal strip (Evans, 1955) were also described.

A simple mechanical shutter-release unit consisting of a baited string attached to a bait pedal of a mouse trap was tested, but did not work satisfactorily. The light pull of some animals failed to release the spring, and the baited string, 4 to 6 feet in length, was often frozen or held to the ground. An electrical device for depressing the shutter release, which is described in this paper, was then developed. Only a very light pull on a short baited string is required to operate the mechanism of this unit. It proved to be a reliable method under the conditions encountered during the seed study in southern Michigan; and further tests indicated other possible uses in wildlife research.

### Description of the Shutter-release Unit

The camera and a part of the shutter-release mechanism were enclosed in a wooden carrying case which provided a mounting panel and protection from the weather. The box, as shown in Fig. 1, was just large enough to hold conveniently the camera and shutter-release mechanism. The top was hinged to provide easy access.

The camera (a Brownie Hawkeye, flash model) was small, inexpensive, and of rugged construction, with a large durable shutter release, a fully protected shutter mechanism, and a small reliable synchronized-flash unit. The camera was held solidly in a box by four small wooden blocks at the base of the four sides of the camera, and by a single piece across the top, secured by two metal hooks which could easily be moved to facilitate removal of the camera for advancing and changing film.

Fig. 1. The automatic unit for releasing the camera shutter mounted in a box. The unit is "set" for taking a picture.

The electrical device for releasing the shutter consisted of a solenoid, a mouse trap, two knife switches, and a dry-cell battery (Fig. 2). A spring-driven wire was made by bending the bow of a mouse trap to a "V" shape, so that it would fit into the shutter-release slot on the camera. The trap was then mounted on the side of the box, so that the bow would depress the camera-shutter release. One of the knife switches (Fig. 2, A) was mounted on the side of the mouse trap, so that when the bow of the mouse trap was released, the knife switch was opened. A solenoid[2] was then mounted above the mouse trap so that the moveable solenoid bar, when extended from the solenoid, retained the locking bar of the mouse trap in a vertical position (Fig. 1).

The other knife switch (Fig. 2, B), used to complete the electrical circuit, was mounted in a small wooden box with a thread for bait, 12 to 18 inches in length, attached to the arm. A wood or metal cross piece was mounted in the box to support the arm of the switch in a vertical position when the circuit was open and the photographic unit "set" for a picture.

A six-volt dry-cell battery was placed in the box with the camera, and connected with the solenoid (Fig. 2). A second connection was made from the solenoid to the adjacent knife switch. This switch

[1] Approved for publication by the Michigan State University Agricultural Exp. Stn. as Journal Article No. 1687.

[2] A Phil-Trol 411006 DC–AU Actuator, manufactured by the Phillips Control Corporation, Joliet, Illinois.

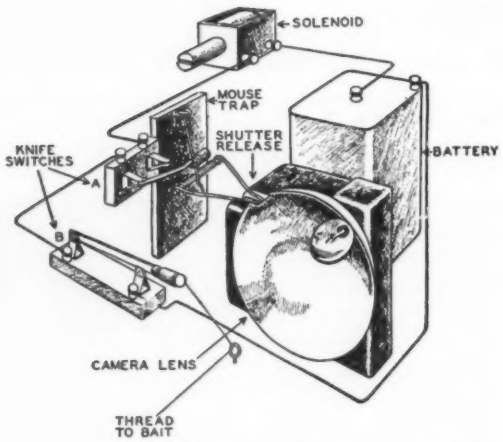



Fig. 2. A diagram of the entire unit for releasing the camera shutter. This indicates the position of the parts after a picture has been taken.

was then connected by a long wire to the knife switch in the separate small box. The circuit was then completed by a wire from this knife switch back to the battery.

Action is fast when the animal takes the bait. A pull on the thread closes the knife switch completing the electrical circuit. The current creates a magnetic field in the solenoid causing the solenoid bar to be retracted. This action releases the locking bar of the mouse trap, which in turn releases the bow of the trap. In its downward movement, the bow opens the knife switch and depresses the shutter release. The knife switch acts as a circuit breaker.

An inexpensive, effective electromagnet, which may be used in place of the solenoid to release the bow, can be obtained from a doorbell. The bell and the tip of the striking bar are removed and the end of the bar is then bent, so that it will hold a flat-headed screw with a slot in a vertical position. A small metal eye is put on the side of the box above the top end of the trap, and a piece of stiff wire is attached. This wire holds the locking bar in a vertical position and reduces the spring tension against the electromagnet mechanism. The electromagnet is then mounted adjacent to the mouse trap so that the tension-reducing wire will fit into the slot of the screw.

This circuit is designed so that when it is completed by the arm of the knife switch, the current activates the electromagnet which draws the striking bar. This releases in sequence, the tension-reducing wire, the locking bar, and the bow of the mouse trap which opens the knife switch and depresses the shutter release of the camera.

## INSTRUCTIONS FOR USE

A fast film should be used for best results, and for accurate identification most animals should be photographed as closely as possible. Experiments with the camera unit during all seasons for over two years in Michigan indicated that rain and cold weather do not generally affect the apparatus, although it was at times necessary to remove snow from the lens and bait. A glass cover, to protect the camera and tripping unit from rain and snow, can easily be inserted into the slots in the sides of the box if desired; however, some reflections from the glass would show on the film.

With only slight modifications this automatic shutter-releasing device can be used with other inexpensive cameras such as the Brownie Holiday Flash Camera; however, the eye-level finder of this camera is not as easy to use as a two-lens reflex type.

## EXPERIMENTAL USES

As a part of a research project, six camera units with automatic shutter-releasing devices were baited with tree seeds and other foods. These units were set 65 feet apart in a 12-acre woodlot, and moved 50 feet every three days to determine what animals were utilizing the seeds during the winter and spring. The bait was readily taken, and the animals were easily identifed from the photographs (Fig. 3).

Fig. 3. A fox squirrel (*Sciurus niger*) photographed with the automatic unit. The separate knife switch is in the small box at the left of the picture.

The units were found to be useful in other research problems. In one case, the camera was baited with a dead rabbit to determine possible reasons for the occasional loss of a trapped animal. The pictures showed that a skunk (*Mephitis mephitis*) came to the bait. In another problem, camera units were baited with dove eggs in an effort to determine the cause of egg losses noted in certain nests under observation. The camera recorded a red squirrel (*Tamiasciurus hudsonicus*) and a blue jay (*Cyanocitta cristata*) taking eggs. During the study of fox in another area, tripping wires from several camera units were placed across den entrances. The results in photographs indicated the size of the foxes using the den. In another study the kinds of animals using the different kinds of ground dens were determined by photographs.

LITERATURE CITED

BENTER, W. P. 1934. Apparatus for wildlife photography. Nature Mag., 23:154.

EVANS, E. H. 1955. Camera trails. Nature Mag., 48:160-161, 164.

KARCHER, E. K., JR. 1938. Photography at nesting time. Amer. Photography, 32:202.

ROZELLE, H. W. 1954. Animals take self portraits. Mechanix Illustrated, 50:180-181.

SHEPARD, S. 1953. How I hunt with a camera. Pop. Sci., 162:182-186.

WING, A. 1948. Electric remote control for self-cocking shutters. Amer. Photography, 42:387.

Received for publication November 15, 1954.

# PROLACTIN: AN EVALUATION OF ITS USE IN RING-NECKED PHEASANT PROPAGATION

*Charles G. Crispens, Jr.*[1]

Ohio Cooperative Wildlife Research Unit, Ohio State University, Columbus, Ohio

This study was undertaken to evaluate the adoption method of ring-necked pheasant propagation, using the hormone prolactin to induce broodiness. It was felt that this method, if feasible, would serve as a useful technique in the introduction and establishment of certain species of gallinaceous birds.

In Missouri, Stanford (1952) reported on the outcome of an adoption experiment in which bob-white quail (*Colinus virginianus*) were used. In this study, broods of 15 to 20 chicks, ranging from 9 to 16 days old, were placed in boxes with pairs of untreated adult quail. After they had remained together for one night, broods in which one or both of the parent birds had adopted the chicks were selected and released on two large tracts. Subsequent records showed a 1.1 per cent recovery of the young birds and an 8 per cent recovery of the adult birds.

## PRELIMINARY INVESTIGATIONS

Twenty-seven female ring-necked pheasants (*Phasianus colchicus torquatus*) were used to ascertain the minimum amount of prolactin needed to induce broodiness. A daily dosage of 6 mg. of prolactin was administered, and the number of days each bird received injections varied from one to six. At the end of the injection periods, two white leghorn chicks (2 weeks old) were placed with each hen. Eight of the 10 hens receiving injections for three days or more became broody, indicating that a dosage of 6 mg. of prolactin per day for three days should be sufficient. Of the four control birds, each of which received injections of 6 mg. of distilled water per day for 3 days, one became broody.

In order to gain some knowledge of the behavior of treated hens and their chicks under natural conditions, preliminary releases were made in a 5-acre enclosure at the Olentangy Wildlife Experiment Station, Ohio. During the afternoon of February 17, 1954, six hens and their chicks were placed as units in six release boxes; these were taken to the release area that evening. Brush was piled around each box and the doors opened after enough time had elapsed to permit the hens and chicks to become quiet. These operations were conducted after dark without the aid of lights.

Extensive observations were begun the following morning and continued for a period of ten days. During this period, temperature extremes of 20° to 50° F., wind velocities of 5 to 50 m.p.h., rain, and clear weather were experienced. In addition, the area was cultivated into strips 5 to 10 feet apart while some of the birds were still in the enclosure.

Within several hours after leaving the release boxes, the six hens and their chicks had formed three units of two hens and six chicks each. Unit 1 remained together for eight days. On the eighth day four of the six chicks were alive and being brooded by the hens. On the ninth day the two hens could not be found. Unit 2 remained together for more than ten days. It had eight chicks with it at this time. All of the chicks succumbed, however, during a week of heavy snows and low temperatures. Unit 3 broke up after four days. Four of the six chicks in this unit were dead; the remaining two were subsequently found traveling with the birds comprising Unit 2.

The two hens in Unit 3 were (a) the control bird that had become broody after the chicks were placed with her and (b) an experimental bird that required an exceptionally long period of time to become broody (over 100 hours). The length of time required for these birds to become broody, plus their subsequent behavior when released (desertion of the chicks), indicated a broody response brought about primarily by the presence of chicks. This is in keeping with what Collias (1946) reports.

## FINAL INVESTIGATIONS

In order to have adequate facilities for holding a large number of hens during the injection period, 26 pens, each being 18 in. x 18 in. x 12 in., were constructed of one-half-inch wire mesh. Each pen was provided with a feeding tray and a water container. The 26 pens were placed as a battery of pens on a platform 3 feet above the ground. They were covered with roofing paper to protect the birds from rain and to provide shade on sunny days. In addition, pieces of burlap were hung over the fronts of

[1]Present address: Department of Zoology, State College of Washington, Pullman, Washington.

the pens to reduce excitement of the birds by passing automobiles and curious onlookers.

Twenty-six release boxes were constructed, each box being 20 in. x 20 in. x 12 in. The sides of these boxes were made of one-half-inch wire mesh covered with burlap. The tops and bottoms of the boxes were made of Upson board. Sawdust was placed on the floors, and food was provided in each box before the releases were made.

The female pheasants were placed in the injection pens the day before the injection period was to begin. Each bird received 6 mg. of prolactin per day for a period of three days. These injections were made subcutaneously in the leg (femoral region) using a 2-cc. syringe and a #20 needle. At the end of the injection period two pheasant chicks were placed with each hen. It was hoped that the chicks could be held in the injection pens with the hens, but this was not possible, inasmuch as the chicks could not adjust to the wire floors. It was necessary, therefore to hold the hens and chicks in the release boxes.

The adult female pheasants and game-farm pheasant chicks were observed for 48 hours. The following criteria of broodiness were used to determine adoption of the chicks by the hens: (1) brooding of the chicks under the wings or body of the adult bird; (2) clucking by the adult bird; (3) protection afforded by the adult bird when the chicks were alarmed; and (4) attentiveness of the adult bird to the chicks. Hens that had not become broody within 48 hours were removed from the release boxes. Hens that had become broody were given an additional eight chicks (total of 10 chicks), loaded on a two-wheel trailer, and taken to the release area.

The releases were made on the Delaware Reservoir Area, a tract of approximately 5,000 acres that is located near the city of Delaware, Delaware County, Ohio, and is managed by the Ohio Division of Wildlife and the Ohio Division of Parks for recreational purposes. This land was formerly used for general farming, but since its acquisition by the state of Ohio it has not been cultivated to any extent. The vegetation consists primarily of heavy stands of grasses and weeds and scattered woodlots. High populations of ring-necked pheasants and other upland game species are to be found on this area; these are supplemented at various times of the year by releases of pen-reared stock.

The release boxes were carried into the field and placed at pre-arranged sites. The doors of the boxes were opened after dark, special care being taken to disturb the birds as little as possible. The boxes were not disturbed for 2 days; they were then picked up and brought back to the laboratory.

A numbered fingerling fish tag was placed in the leading edge of the right wing of each chick before it was released. In addition to the tag, scales on each leg were branded in various combinations. The branding procedure followed was similar to that described by Wandell (1943), in which a wood-burning tool was used to disfigure the scales.

One hundred and twenty-three pheasant hens (112 pen-reared birds and 11 wild birds) were obtained and separated into 5 injection-release groups. Seventy-two of the 112 pen-reared hens (64 per cent) and 10 of the 11 wild birds (91 per cent) became broody. These 82 hens and 820 chicks (10 chicks per hen) were released on the Delaware Reservoir Area. The first release was made on May 26, 1954; the others followed at intervals of approximately one week with the fifth and final release being realized on June 29, 1954.

The number of birds that became broody was much lower than had been anticipated. This was particularly true of the pen-reared birds. Godfrey and Jaap (1950) found that the broodiness of domestic hens could be interrupted by confining the birds in small pens for periods of 3-6 days. In an effort to determine whether the size of the holding pen was of any significance in this experiment, 8 of the 20 hens comprising the final injection-release group were held in larger pens (36 in. x 30 in. x 24 in.). Seven of these birds (88 per cent) became broody while 10 of the 12 birds (83 per cent) held in the release boxes became broody. A lack of significance when larger pens are used is indicated.

The ages of the chicks when released varied from 3 to 37 days. Twenty-eight of the 820 chicks released (3.4 per cent) were found dead in or near the release boxes, leaving a total of 792 chicks still alive after one night in the field with their "foster parents." Assuming a sex ratio of 50:50, there were 396 male chicks available for harvest during the hunting season if all of the 792 chicks survived until that time. Suffocation and trampling during transportation to the release area were judged to be the cause of death for 22 of the 28 chicks.

Periodic observations were made of the release areas and surrounding territory twice a week during the period July 5 to August 10, 1954, in order to locate and identify a segment of the released population. A total of 11 released hens was seen in this manner. Three of the hens had no chicks; the remaining eight hens had a total of 48 chicks traveling with them. Hens were identified by an aluminum leg band on their right leg. Positive identification of each chick was not possible, but it was assumed that they were the same chicks that had been released with the hens. The ages of the chicks when seen ranged from 9 to 11 weeks.

During the small-game hunting season (November 15, 1954, to January 1, 1955) hunter-checking stations were operated on the Delaware Reservoir Area. A hunter killing a pheasant on this area was required to check it through one of these stations. Returns from the checking stations accounted for only 2 of the estimated 396 males that were released. Four females, all "foster parents," were also killed. Three of these birds were pen-reared hens, and one was a wild hen. Both of the males were killed on the opening day of the season. Bird A was 10-12 days old when it was released. Its "foster parent" was a pen-reared hen. Bird B was 17-20 days old when it

was released. Its "foster parent" was also a pen-reared hen. Bird A was shot a considerable distance (one-half to one mile) from the point of release. Bird B was shot in or near the area in which it had been released. All four of the hens were killed in, or in close proximity to, the areas in which they were released.

## DISCUSSION

Needless to say, the recovery of birds released as chicks was disappointing in terms of encouragement for this technique. It seems fitting and proper, however, to discuss some of the factors that may have contributed to this small harvest of the birds released.

One possible explanation for the small kill of released birds is that the hens failed to remain broody and care for the chicks. Preliminary laboratory investigations indicated, however, that hens could be expected to remain broody and care for chicks for relatively long periods of time. It must be remembered, however, that these data were obtained at a time (January–April) when the physiological conditions of the birds were quite different from the time (May–June) that the final investigations took place. In addition, the relatively small sample size used to obtain these data could have resulted in a rather poor estimate of variability.

Predators undoubtedly accounted for some loss. The killing of one hen within the first few weeks after the releases were made would probably result in the loss of all chicks released with her, since it is rather doubtful that chicks (2 to 5 weeks old) can survive in the field completely on their own.

Careful weather records (minimum temperature, maximum temperature, and precipitation) were kept for the period May 23 to July 7, 1954. During the first two weeks of this period (May 26 to June 8, 1954) the average daily minimum temperature was only 51.7° F., with several temperatures of less than 40° F. recorded. In addition, there was a total rainfall of more than 2.00 inches and at least one storm with wind velocities that exceeded 70 m.p.h. The chicks during this time were 3 to 14 days old. Weather conditions during the last four weeks of the period (June 9 to July 7, 1954) were much more favorable. The average daily minimum temperature during this latter period was 60.9° F., with no record of a temperature below 50.0° F. on any night. Although there was considerable precipitation (approximately 4.00 inches), there were no torrential storms. It does not seem unreasonable, therefore, to conjecture that unfavorable weather conditions accounted for some reduction in sample size, at least insofar as the first two release groups were concerned.

Even if it is assumed that such factors as the failure to remain broody, predation, unfavorable weather conditions and possibly other factors caused the deaths of some part of the population, we still must reckon with the failure to harvest more birds even though a large number of chicks (9 to 11 weeks old) was seen associating with the "foster parents" late in the summer. Two possible explanations for this are: (1) although positive identification of the hens was possible after they were released, it can only be assumed that the chicks observed with the hens were those which had been released with them, and (2) it is probable that a number of these birds dispersed beyond the limits of the reservoir area, either because of competition with an already large population of pheasants or because of an accentuated hunting pressure (3,600 hunters on the first day alone).

## ACKNOWLEDGMENTS

This study was made possible by a Wildlife Research Fellowship granted and maintained cooperatively by the Wildlife Management Institute, The Ohio Division of Wildlife, The Ohio State University and the U.S. Fish and Wildlife Service. The author is grateful to Dr. Eugene H. Dustman, leader of the Ohio Cooperative Wildlife Research Unit, under whose direction this study was made.

## SUMMARY

An evaluation of the adoption method of ring-necked pheasant propagation, using prolactin to induce broodiness, was conducted during the fall of 1953 and year of 1954 at the Ohio State University and the Delaware Reservoir Area in Delaware County, Ohio. Preliminary investigations with twenty-seven female ring-necked pheasants indicated that a minimum of 6 mg. of prolactin per day for three days was sufficient to produce broodiness. One hundred and twelve pen-reared pheasant hens and 11 wild pheasant hens received injections of prolactin during the final investigations. Eighty-two of these birds became broody and were released with 820 pheasant chicks on the Delaware Reservoir Area. Twenty-eight chicks were found dead after the releases, leaving a total of 792 chicks still alive after one night in the field. Returns from hunter-checking stations operated during the small-game season accounted for only two of the estimated 396 males that were released. Possible explanations for the small return of released birds include: predation, severe climatic conditions, failure of hens to remain broody, and a high rate of dispersal of birds off of the area.

## LITERATURE CITED

COLLIAS, NICHOLAS. 1946. Some experiments on broody behavior in fowl and pigeon. Anat. Record (Supplement), 96:572.

GODFREY, E. F. AND R. GEORGE JAAP. 1950. Estrogenic interruptions of broodiness in the domestic fowl. Poultry Sci., 29(3):356-361.

STANFORD, JACK A. 1952. An evaluation of the adoption method of bobwhite quail propagation. Trans. N. Amer. Wildl. Conf., 17:330-337.

WANDELL, WILLET N. 1943. A multi-marking system for ring-necked pheasants. J. Wildl. Mgmt., 7:378-382.

Received for publication September 6, 1955.

# TELEVISION AS A WILDLIFE-EDUCATION MEDIUM

*Douglas L. Gilbert*[1]

Colorado Game and Fish Department

The need for conservation education in the broad sense has recently become increasingly important in securing better use of our natural resources. Wildlife education, as related primarily to conservation, has also been increasing in importance due to a greatly increasing army of hunters and fishermen. Keeping pace has been a corresponding need to educate the expanding hunting and fishing public on the identification and habits of wildlife, rules and regulations, and the reasoning behind these regulations.

During the past decade television has been added to radio, newspapers, and personal appearances as a group-education medium. This method of reaching the public has many obvious advantages. It is more vivid, more real, more stimulating and demands more sustained attention than radio; it is more intimate and closer at hand than films; and the size of the audience reached is far greater than can be contacted through personal appearances.

Realizing the potentialities of television as a medium of wildlife education, the Colorado Game and Fish Department in Grand Junction started, on June 12, 1954, a weekly television show over the first and only television station in that area. Known as "Wildlife in Review," the program has for more than one and one-half years been favorably received in western Colorado and parts of eastern Utah. It is hoped that a review of the planning, performance, and content of this program will reveal some of the particular aspects of the usefulness of television and suggest possibilities to be explored by those who are interested in utilizing television as a medium of wildlife education.

## Problems Involved

The first question to arise is whether a show of this type should have a sponsor. Ideally the time should be bought by the Conservation Department. Here, however, cost is usually prohibitive. To make a show permanent, a sponsor is necessary; otherwise a station, which must make money like any other business, may be forced to sell the time to a sponsor with another program. Such was the case with at least one other Game and Fish Department show in Colorado.

The type of sponsor offers the next question. At first thought it would seem that a sporting-goods store would be ideal. Here, however, the feeling may arise that the Department is sanctioning one store's merchandise over another. It is therefore believed that the best firm or agency for sponsoring a game and fish program is one that is unrelated to hunting and fishing and the equipment used in these sports in any way.

Other problems involved are the length of the show, the time to be allowed for commercials, and the person to do the commercials. A weekly fifteen-minute program seems to be best. The program moves fast, holds attention, and yet there is no difficulty in filling the time. The usual procedure is to give three of the fifteen minutes to commercials. In Colorado, this three minutes was distributed in two parts, allowing a short commercial before and after the main part of the program. The commercials may be done either by a station employee or the Department employee. If done by the Conservation official, it is suggested that a uniform not be worn, again to avoid Department sanction of any type of merchandise.

The necessity is always present of keeping the sponsor satisfied and feeling that he is getting full value received for money spent on this type of advertising.

## Operation

The sponsor of "Wildlife in Review" was the largest plumbing, heating, and sheet-metal concern in Grand Junction. A contract was signed to sponsor the program for one year starting July 27, 1954, after this company had had opportunity to see several programs that were sponsored by the station until a buyer could be found. The commercials were to take three minutes of every fifteen-minute show. Of necessity, due to a lack of permanent station personnel, it was decided that the Game and Fish officer would do the commercials. These commercials consisted of showing appliances and stressing their good points and method of operation, or of short films.

## Programs

Every effort was made to keep the programs entertaining as well as educational and informative. Basically, four sources of material were used: motion pictures of the desired length and type; colored slides with corresponding lecture; various "props" such as licenses, maps, dead game, horns, antlers, study skins, and skulls—all with corresponding lecture; and the use of live animals and birds. Inter-

[1]Present address: School of Forestry, Colorado A. and M. College, Ft. Collins, Colo. The author is indebted to the Colorado Game and Fish Department and the employees therein who assisted with many of the programs. Thanks are due station KFXJ and Lane and Company, a plumbing, heating, and sheet-metal firm in Grand Junction, Colorado. The Colorado Cooperative Wildlife Unit furnished some of the materials.

views were used very sparingly due to a tendency toward dullness. The following is a complete listing of programs for 52 weeks. Whenever possible they were coordinated with corresponding "on the ground" wildlife problems, situations, and seasons.

1. The first show featured the Director and Assistant Director of the Colorado Game and Fish Department. Current and future happenings within and concerning the Department were discussed. Some time was given to future programs.

2. Live trout, from 15 to 24 inches long, were shown from an aquarium. Each trout was caught in a dip net and its identifying characteristics, food, habitat, size, and weight were described and discussed. A fish was accidentally dropped and afforded action, which added to the program. This program tied in very well with liberalized bag limits on certain species of trout. One suggestion was to have a good comparative scale to indicate fish size. Ample time should be allowed for setting up the aquarium in the studio.

3. This was a duplication of number two except that various warm-water fish were used. The fish presented include white bass, largemouth bass, sunfish, bluegill, and carp.

4. This program was based on pheasant mortality factors. A flushing bar was shown and its operation explained. Live predators of the pheasant, which included a striped skunk and magpie, were shown. Other props were live pheasants of both sexes and several ages, and pheasant eggs. Two colored slides were used to depict the effect of mowing machines on pheasant nests.

5. Colored slides on fish planting made up this program, which covered methods of stocking with the aid of horses, trucks, back packs, and airplanes.

6. An electric system of shocking fish was set up in an aquarium. The effects of attraction and repelling were explained and illustrated with small fish. The field use of this technique was given.

7. A film was shown on fish-salvage operations.

8. A film was shown on big-game species and their identification. This was an early prelude to the coming big-game hunting season.

9. Additional warm-water fish were shown in an aquarium and presented individually. This was a continuation of number three. Fish used were catfish, bull head, wall-eyed pike, rock bass, crappie, and goldfish. The catfish used in this show weighed approximately 27 pounds.

10. A tame, half-grown bobcat was the feature attraction. The cat was fed a bottle of milk to quiet it during the program. Discussion included identifying characteristics, life history, habitat, food, role as a predator, and fur value.

11. Two mule deer fawns, which were still spotted, were used. Subjects discussed included coloration and camouflage; why fawns should not be picked up; the tagging program, and its value along with the tags in their ears; plus mule deer fawn characteristics and habits.

12. A film was shown on grouse.

13. Just previous to the bighorn sheep season, this show was devoted to bighorn sheep. A five-minute film was used with the rest of the time showing heads of both sexes and methods of aging, and discussing bighorn problems in Colorado, characteristics of the species, and other pertinent information regarding the coming hunt.

14. The approaching grouse season was discussed and the various regulations were explained. Study skins of the species on which the season would be open were shown. These included ptarmigan, sage grouse, and dusky grouse. Hunting methods and areas were covered, as were regulations and characteristics of the birds.

15. The approaching antelope seasons were reviewed and regulations covered. The antelope was discussed as to taxonomy, habitat, concentration, and other characteristics. Several 8- by 10-inch black and white photographs on trapping were used.

16. Many questions regarding the coming turkey season were answered. The birds were discussed as to habitat and other characteristics of the species. The best hunting areas, laws, and the equipment to use were given. Two kinds of turkey calls were demonstrated.

17. The topic was "why have different big-game seasons in different areas of the state." The discussion included how the seasons are set; the various "tools" of the game manager, such as preseasons, postseasons, liberal bag limits, and their use; and tips on hunting and the best hunting areas. Charts and maps were used that showed problem areas and land ownership. Tagging and other regulations were reviewed.

18. A large, four-point mule deer was hung up, skinned, and partially cut up in front of the camera. The high point was in showing how one man can hang up a heavy animal using a gambrel. The hide was partly removed before the show due to time limitations. The discussion included how to take care of wild meat starting from shooting time and ending in the locker or freezer.

19. Colored slides on deer and deer problems made up this entire show. Subjects covered were either-sex seasons, migrations, the effect of man-made structures such as canals, roads, and fences, and winter range problems.

20. Previous to the coming duck season, this program showed the steps in setting migratory-bird seasons. Props included flyway charts and study skins to illustrate interspecific identification. Duck calls were demonstrated, as were decoys.

21. The coming upland-game-bird seasons afforded the subject for this program. Live birds were used, including male and female pheasants, Gambel's quail, and scaled quail. The seasons and their regulations were thoroughly covered.

22. Sportsmen-landowner relationships were discussed. Various colored signs showing the degree of posting by the landowner were covered as a local club project. Sportsmen's ethics were thoroughly outlined.

23. Duck trapping and banding operations were explained. Four live ducks were banded in front of the camera. The main topic was why band and what information is obtained from these bands. Models of the Colorado duck traps and cannon set were shown.

24. A live raccoon and badger were the attraction. Characteristics of these animals were discussed and described.

25. A group of furs, including badger, coon, coyote, bobcat, red fox, gray fox, marten, mink, muskrat, ring-tailed cat, and ermine were shown and discussed. Fur prices, trapping methods, and skinning methods were covered.

26. Two live female brook trout were spawned and one male was used to fertilize the eggs. Methods of measuring and packing the eggs were then shown.

27. The topic for discussion was horns and antlers and their difference. Subjects included manner of growth; which are shed and how; methods of aging, records, and abnormalities. Many horns and antlers were used as examples.

28. A 12-minute film on the use of the airplane in game counts was shown. Subjects included counting methods, best weather and time, hazards involved, and the various jobs done in game management with the plane. The film showed how deer and elk appear from the air. Past trends and results were covered.

29. A live raccoon and opossum were shown. Habits of both were discussed. This included identifying characteristics, food, habitat, and fur values. Two colored slides were used to show young opossums in the female's pouch.

30. A 12-minute film on beaver was used.

31. A live, one-fourth–grown mountain lion was shown. The animal was cross-chained to facilitate handling. The manner and method of catching and running lions with dogs was covered, along with food habits, characteristics, range, and actions. The bounty system and its merits as well as the economic value of mountain lions were presented.

32. Live beavers were used. Subjects included methods of trapping, food habits, identifying characteristics, range, and actions. A critical examination was made of the animal's teeth, feet, tail, ears, and lips. Economic aspects were covered.

33. This show illustrated the method of skinning beavers and stretching their pelts. Discussion included pelt value, size, and primeness.

34. The skulls and feet of a grizzly bear, brown bear, raccoon, mountain lion, bobcat, coyote, fox, marten, mink, opossum, elk, mule deer, bighorn sheep, and antelope were shown. Discussion covered tracks, aging methods, the relation of teeth to food habits, jaw articulation, and other skull characteristics and food differences.

35. This program was devoted to magpies and magpie-control methods. Live birds were shown, as was a magpie trap.

36. This program was on mink ranching. The various color phases were shown and discussed. Their food, value, and other characteristics were covered. Cages and methods of handling were demonstrated.

37. Study skins of 15 different raptorial birds were used as props. Discussion covered the identifying characteristics of the falcons, buteos, and accipiters, plus their respective good and bad qualities. Governing laws were given.

38. The tagging of a live deer constituted the program. The animal was retained in a carrying box for the operation. A model of an individual live trap was shown and explained. Reasons behind the trapping and tagging program and some results were given.

39. This show featured a half-grown brown bear. Discussion included food, breeding habits, laws, dormancy, color phases, and economic values.

40. This show was on traps. Sizes and kinds demonstrated were bear traps, beaver live traps, coyote traps, and several kinds of muskrat traps including single-spring, double-spring, and the "stop-loss" type.

41. Study skins of rabbits and squirrels were used. Other than habits and identifying characteristics, the discussion involved hunting regulations, cycles, and hare and rabbit differences. Animals included fox squirrel, Abert's squirrel, pine squirrel, gray squirrel, rock squirrel, cottontail, coney, white-tailed jack rabbit, and snowshoe hare.

42. A film on antelope-trapping methods and release results in Colorado was shown.

43. Wildlife photography constituted the program. The types of cameras, lenses, and their advantages for wildlife photography were discussed. Several types of blinds were shown.

44. Trapping methods were discussed with a nine-year-old trapper. Pelts were shown and their value anticipated. This show was designed to build up interest in muskrat trapping due to increasing damage by these animals.

45. Live chukar partridges were used. The hope of establishing this bird as a new huntable species in Colorado and the work involved were discussed. The birds were completely described as to sex, age, color, habits, and other characteristics. A plea was made to give the birds as much protection as possible.

46. This show was on sage grouse with a live male as the main prop. The talk concerned description of the birds as to color, size, booming activities, census methods, habitat, and food habits. Seasons and regulations were reviewed.

47. A live ring-tailed cat procured from a local zoo was exhibited. The animal's characteristics, habits, habitat, and description were covered. Further interest was added when the animal barked and bit through the handler's glove.

48. A complete show was done on care of fishing tackle and tackle repair. This included rod straightening, varnishing, wrapping, and ferrule replacement. Fishing laws and prospects for the coming season were reviewed.

49. A fly-tying demonstration afforded material for this program. Steps were covered from start to finish.

50. The Forest Service cooperated in a demonstration of fire building and suppression, care of campgrounds, and water pollution. A fire was built in a large container of dirt, and the audience was shown how to be sure when a fire was out. Various phases of fire prevention, such as care with pipes, cigarettes, matches, and campfires were demonstrated. The results of a forest fire were illustrated with colored slides.

51. A large aquarium was used and fish poisoning demonstrated. Tagging and fin clipping were shown. The reasons for doing these jobs were given.

52. The program was centered on amphibians. Included were salamanders, toads, leopard frogs, and bull frogs. Metamorphosis, foods, enemies, and values were covered. Accent was on the bull frog as a game species and the seasons governing it.

Suggested topics for other shows are poisonous reptiles, nonpoisonous reptiles, horse packing, back packing, camping, tents, camp cookery, taxidermy, gun safety, archery, bird dogs, porcupine, marten, and fox. It is easy to see that suitable topics and subject matter are always available. Since the author left for other employment, "Wildlife in Review" has continued under the same sponsor with different personnel. This further attests to the value of such a program to the sponsor, the station, and the conservation agency.

## SUMMARY

The need for wildlife education is increasing with the increasing numbers of hunters and fishermen. Television offers an excellent medium to be utilized in addition to radio, newspapers, and personal appearances. A wildlife television show was very successful in all respects in an area including western Colorado and part of eastern Utah. Problems encountered included the need for a sponsor, the type of sponsor, the length of the show, the length and type of commercial, and who was to do the commercials. Programs should be kept interesting as well as educational. Material used included live and dead animals; study skins; motion pictures; colored slides; and various "props" such as licenses, antlers, horns, skulls, charts, traps, and maps. In Colorado, programs were coordinated, where possible, to explain, discuss, or defend wildlife problems, situations, and seasons. Material is not lacking for this type of program.

Received for publication February 28, 1956.

# MINIMUM LETHAL TEMPERATURE FOR THE COTTONTAIL PARASITE *Eimeria environ*

*Dean H. Ecke*

Santa Clara County Health Department, San Jose 28, California

During a survey of cottontail parasites in Illinois, Ecke and Yeatter (1956) discovered that storage by refrigeration often destroyed coccidian oöcysts. The high natural rate of infection in adult rabbits (over 90 per cent in the above study) results in a massive accumulation of oöcysts in manure deposits—particularly in areas of heavy rabbit density. If the oöcysts remain infective, a vast reservoir is accumulated over winter as a potential danger to the young, susceptible rabbits in the spring. The effects of cold temperature on this disease reservoir thus become an important consideration to the game manager. The present study was undertaken to determine the lower temperature tolerances of the organism. The results herein reported were included as a part of a Master's thesis submitted to the University of Illinois in 1947.

The coccidia used for experimentation were of the species *Eimeria environ*. A supply of organisms was available from a captive juvenile rabbit that was infected when taken from its nest. Oöcysts were recovered by collecting freshly deposited droppings from the litter pan under the animal's cage. The pan was thoroughly cleaned prior to collecting so that all oöcysts were less than 12 hours old when collected and sporulation could not have commenced.

Constant low temperatures were maintained within two degrees of accuracy by placing a thermostatically controlled, heated box inside of a freezer-type refrigerator. Temperature control could thus be maintained between +10° and -25° Centigrade.

A series of experiments was conducted to test the survival of *E. environ* at temperatures of 0°, -5°, -10° and -15°C. Four petri dishes containing freshly collected pellets from the infected rabbit were placed in the control box for exposure at each of these different temperatures. For each temperature level, a dish was removed at the end of 12, 24, 48, and 72 hours. At the time of removal, the contents of the dishes were placed in 2½ per cent potassium dichromate and allowed to remain at least four days. At the end of this interval the oöcysts were concentrated by sugar flotation and examined under the microscope. Oöcysts that failed to sporulate were considered inactive (dead).

Controls were established for each series by placing comparable samples from the same collection directly in potassium dichromate when collected and comparing the sporulation rates with those of the exposed samples. Survival percentages were computed by dividing the number of sporulated oöcysts in a microscopic sample by the total number of oöcysts present. Table 1 summarizes the results.

These experiments indicated that oöcysts of *E. environ* become incapable of sporulation and are consequently noninfective after 48 or more hours of exposure to a temperature of -15°C.

TABLE 1. — EFFECTS OF LOW TEMPERATURES ON THE VIABILITY OF OÖCYSTS OF *Eimeria environ*

| Length of Exposure (hours) | Per cent Survival Following Exposure of Fecal Pellets at the Following Temperatures (Centigrade) | | | |
|---|---|---|---|---|
| | 0° | −5° | −10° | −15° |
| 0 (controls) | 99 | 100 | 78 | 77 |
| 12 | 96 | * | 37 | — |
| 24 | 97 | * | 44 | 44 |
| 48 | 99 | * | 38 | 0 |
| 72 | — | * | 45 | 0 |

* Percentages were high but not calculated.

Note: At 0° the fecal pellets did not freeze; at −5° they became frosty but did not freeze solid. The pellets were frozen solid at −10° and −15°.

## DISCUSSION

Several reports have been published on the effects of heat on coccidia (Becker and Couch 1931, Reinhardt and Becker 1933, Chang 1937, and Christensen 1939), but little has been written on the effects of low temperatures on *Eimeria*. Christensen (1939) reported that temperatures ranging between 0° and -5°C. tended to slow sporulation and thus preserve oöcysts of *E. arloingi*, but he made no mention of the lower lethal temperature for the species. Perard (1925), working with *E. perforans* and *E. stiedae*, showed that temperatures of -15°C. were fatal to 50 per cent or more of oöcysts, depending on their location in rabbit "pellets." However, he did not mention the length of time that caused mortality, and viability was determined by the observed "condition" of the protozoa and not their ability to sporulate. Landers (1953) presented evidence that unsporulated oöcysts of *E. arloingi*, *E. ninakohl-yakimovi* and *E. parva* of sheep could withstand prolonged or intermittent exposure to temperatures of -19°C. without decreased viability. His experiment suggested that -25°C. is very close to the minimum survival temperature for these species, and he pointed out that surface temperatures in the vicinity of Laramie, Wyoming, seldom go this low.

Most winters in Illinois produce cold spells of 48 or more hours duration in which air temperatures remain below -15°C. (+5°F.). Temperatures at ground surface should compare with air temperatures unless some protection is available (*i.e.* snow cover, matted vegetation, etc.). In light of the present findings one might speculate that rabbit die-offs could be expected in the spring following a mild winter. More study is needed to determine ground surface temperatures and lethal temperatures for other species of rabbit *Eimeria*.

### SUMMARY

Experiments were conducted under laboratory conditions to determine the lower lethal temperatures for *Eimeria environ*, a common parasite of the Illinois cottontail. It was found that 48 hours at a temperature of -15°C. proved fatal to 100 per cent of exposed coccidia. The implications are that cold weather would destroy much of the infection in contaminated ground; conversely, a mild winter could permit a massive build-up of viable oöcysts and might result in a high mortality of young rabbits from coccidiosis during the following spring.


### REFERENCES


BECKER, E. R., and H. B. COUCH. 1931. Some effects of temperatures upon development of oöcysts of coccidia. Proc. Soc. Exp. Biol. and Med., 28:529-530.

CHANG, K. 1937. Effects of temperature on the oöcysts of various species of *Eimeria*. Am. J. Hyg., 26:337-351.

CHRISTENSEN, J. F. 1939. Sporulation and viability of oöcysts of *Eimeria arloingi* from the domestic sheep. J. Agri. Res., 59:(7):277-284.

ECKE, D. H., and R. E. YEATTER. 1956. Notes on the parasites of cottontail rabbits in Illinois. Trans. Ill. Acad. Science, 48:208-214.

LANDERS, E. J. 1953. The effects of low temperatures upon the viability of unsporulated oöcysts of ovine coccidia. J. Parasit., 39(5):547-552.

PERARD, C. 1925. Recherches sur les coccidies et les coccidioses du lapin. II. Contribution a l'etude de la biologie des oöcystes des coccidies. Ann. Inst. Past., Paris, 39:505-542.

REINHARDT, J. F., and E. R. BECKER. 1933. Time exposure and temperature as lethal factors in the death of the oöcysts of *Eimeria miyairii*, a coccidium of the rat. Ia. St. Coll. J. Sci., 7:505-510.


Received for publication January 4, 1956.

# ARANSAS REFUGE WILDLIFE INTRODUCTIONS


*Arthur F. Halloran and Julian A. Howard*

U.S. Fish and Wildlife Service, Cache, Oklahoma


The Aransas National Wildlife Refuge is well known by the public as the winter home of the whooping crane (*Grus americana*). Game managers also know of it as the home of the prolific deer herd that has provided 11,570 surplus deer during a 15-year transplanting project by the Wildlife Restoration Division of the Texas Game and Fish Department.

During the 1930's, several species of game were introduced to the area now covered by the refuge. It appears to be of value to record these introductions, and after a lapse, in some cases of 25 years or more, to observe the results.

### LOCATION

Tharp (1952) places the Aransas Refuge in Subregion *b* of the Coastal Prairie Region of Texas. He well describes this 47,261-acre area as follows: "It occupies a low, sandy peninsula largely covered with blackjack oak (*Quercus marilandica*) and live oak (*Q. virginiana*) savanna. Grasses range from coastal *sacahuiste* on the lowest flats to bluestems, dropseeds, muhlies and artistidas in the higher-portions."

The refuge is seven miles from Austwell on the central Texas coast and lies in parts of Aransas, Refugio, and Calhoun counties.

### HISTORY OF THE AREA

Halloran (1943) outlined the history of the Blackjack (St. Charles) Peninsula in his study of the deer and cattle. Before 1919 the area was owned by Cyrus Lucas. In 1919 the management of this ranch was taken over by the San Antonio Loan and Trust Company. About 1923, active operation of the ranch, known as the St. Charles, was assumed by the late Leroy G. Denman, Sr., of the San Antonio Loan and Trust Company (personal communication from Mr. Denman to refuge manager James O. Stevenson, March 4, 1939). Mr. Denman prohibited all hunting and built a game-proof fence across the northern part of the peninsula. The introductions described herein were made by Mr. Denman. The area became a Federal refuge on December 31, 1937, and is now administered by the Fish and Wildlife Service of the U. S. Department of the Interior.

Notes on the game introductions were taken during a one-hour interview with Mr. Denman on the evening of December 27, 1939. These notes, plus records from the refuge files, form the basis of this paper. James O. Stevenson, the first refuge manager of the area, recorded much data on the introduced species in his narrative reports, and this information has been freely drawn upon.

### INTRODUCTIONS

Fallow deer (*Dama dama*). Three color varieties were introduced between November 20, 1930, and August 31, 1936: spotted, black, and white. The deer were purchased from dealers in Alabama and Milwaukee. A few came from the San Diego Zoo. By

the end of 1938 approximately 22 had survived, the remnant of 500 to 600 brought in and released. When the peninsula was purchased by the government, the former owners were allowed to trap the remaining deer. The progress of this program as outlined in the refuge reports is abstracted below. In late 1938, 10 (1 buck, 8 does, 1 fawn) were captured and were shipped to another property of the San Antonio Loan and Trust Company. In 1939 four deer were trapped. The last reference to the deer appears in the report of late 1940 and early 1941 when, in connection with the deer-trapping program it is stated, "... one fallow deer (was) caught ... and given to the former owner ... under an agreement made several years ago."

White-tailed deer (*Odocoileus virginianus*). These deer were native to the area. During the early part of the century, because of hunting and other factors, the resident deer became very scarce. Halloran (1943) records the successful reintroduction of this species by Mr. Denman during the period from 1925 to 1937. During the 1939 interview, Mr. Denman stated that he believed the 1939 herd was made up mostly, if not entirely, from his plantings.

Mule deer (*Odocoileus hemionus*). The purchase records show that this species was introduced during the period from August 8, 1931, to 1935 (from Salt Lake City). Notes from the 1939 interview state that 50 were brought in, but after a few months they started to die. Their antlers were only short protuberances and their hair became "patchy." All of the transplant died prior to 1939. This species is not native to the area (Texas G. F. and O. Comm., 1945, p. 105).

Feral hogs (*Sus scrofa*). At the turn of the century the widely known, ordinary "Texas rooter" hogs were run on the St. Charles Peninsula. The descendants of these animals were present on the area in 1919. Starting in 1930 Mr. Denman introduced European wild boars. Eleven were introduced by June 27, 1933. The skulls of two specimens sent to the U. S. National Museum in August 1955 showed traces of both European wild boar and ordinary pig ancestry (letter to refuge manager Howard from Viola S. Schantz, September 7, 1955).

When the refuge was created, the owners were allowed to trap and remove these wild hogs. They shipped out or butchered approximately 2,500 from October 1, 1936, to October 31, 1938. From this time until July 30, 1939, another 891 were removed. These feral hogs of mixed ancestry are mainly brown or solid black in color. They are fast and vicious and will not hesitate to attack a man when cornered. An August 1955 specimen was estimated to weigh 160 pounds entire and provided 84 pounds of hog-dressed meat. These animals are now competing for range space with the native javelinas (*Pecari angulatus*).

California quail (*Lophortyx californica*). At least 252 California quail were purchased and released on the range between June 30, 1933, and April 2, 1935. None were seen during the field work of 1939-1940 nor during the field studies of 1955.

Ring-necked pheasant (*Phasianus colchicus* ssp.). Both live pheasants and hatching eggs were purchased between May 27, 1933, and 1934 to establish this species on the ranch. At first they appeared to be in good plumage and nested. Nests were found that had been destroyed. No known young were raised. We quote from the narrative report of refuge manager James O. Stevenson for the period November, 1938 to January 31, 1939: "One male was observed in the area between Walker Well and refuge headquarters. On January 5 this bird was found with a broken wing near the ranch house and was collected. A study skin was prepared. This specimen will be forwarded to the Survey collection in Washington. This was one of the last of about 400 birds released in 1934, an unsuccessful introduction to say the least."

Turkey (*Meleagris gallopavo*). Turkeys were native to the area (Aldrich and Duvall, 1955, p. 22), but the best information available indicates that the native stock was extirpated by the time Mr. Denman took charge of the St. Charles ranch. The earliest reintroduction of record is from May 14, 1931; we quote, "210 wild turkey eggs, 50 hatched, 18 lived." A total of 318 birds was brought in by December 16, 1933. The interview notes state that this was the Rio Grande turkey (*M. g. intermedia*) from the King Ranch. Mr. Denman added that this was a very pure strain. Turkeys are found today on the refuge.

## SUMMARY

A history of introductions of exotic game and reintroductions of native game for the period 1925 to 1935 is given for the Blackjack (St. Charles) Peninsula on the central Texas coast on land that is now the Aransas National Wildlife Refuge. Reintroduced white-tailed deer, Rio Grande turkey, and mixed ancestry European wild boars have persisted and increased; fallow deer (some of which were removed), mule deer, California quail, and ring-necked pheasants were not successful.

## LITERATURE CITED

ALDRICH, JOHN W. AND A. J. DUVALL. 1955. Distribution of American gallinaceous game birds, Circ. 34, F.W.S., U.S. Dept. Int., Wash. D. C.

HALLORAN, ARTHUR F. 1943. Management of deer and cattle on the Aransas national wildlife refuge, Texas. J. Wildlife Mgmt., 7(2):203-216.

TEXAS GAME, FISH AND OYSTER COMM., 1945. Principal game birds and mammals of Texas. viii + 149 pp. Austin, Texas.

THARP, BENJAMIN C. 1952. Texas range grasses. Univ. of Texas Press, Austin, Texas. xiv + 125 pp.

Received for publication April 18, 1956.

# PROTECTING GRAIN FIELDS IN JAPAN FROM PILFERAGE BY BIRDS

*H. Elliott McClure*

406th Medical General Laboratory, APO 343, San Francisco

Bird populations over much of Japan are small, but there may be local concentrations at certain seasons of the year and, where these concentrations conflict with farming interests by causing damage to crops, the problem of their control arises.

The crop of greatest acreage and most often subject to damage is rice. Two types of damage are done to it by birds: eating the grain and trampling the seedbeds. The species most often causing damage are tree sparrows (*Passer montanus*), which attack the crop in the late summer during the "milk stage," and herons and egrets, which walk through seedbeds in search of frogs, crustacea, and small fish. Grey starling (*Sturnus cineraceus*) flocks also feed in rice paddies and truck crops, but this species is mainly insectivorous and little damage is attributed to it. Greenfinch (*Chloris sinica*) and brambling (*Fringilla montifringilla*) are sometimes accused of damage, but their flocks are usually of local distribution and damage is small. Two species of crows (*Corvus corone* and *C. levaillantii*) occur in Japan, but flocks of as many as a hundred are rarely seen. Both species are omnivorous and damage to crops, stored foods, or animal products is usually limited to that of a few individuals.

In the United States, rice or grain fields are of large acreage whereas the average field in Japan, owned or operated by one man, is less than an acre. A given farmer may have several fields, but they will usually be small and of irregular size. Since each farmer may plant at a slightly different time or use a different variety of grain, the fields do not mature uniformly. Therefore in a paddy area of 500 acres there will be rice in all stages from "milk" to ready for harvest. This offers a variety of foods to marauding birds.

Although the area of grain per farmer is small, its relative value is much higher than that of a similar size in the United States. The cost of labor appears to be much cheaper by our standards, but judged by the standard of the Japanese farmer the costs of labor and production are high. He has little cash to devote to control methods, and his margin of profit when he sells the grain is so narrow that any increase in production costs may wipe it out.

In Japan the solution to this control problem rests

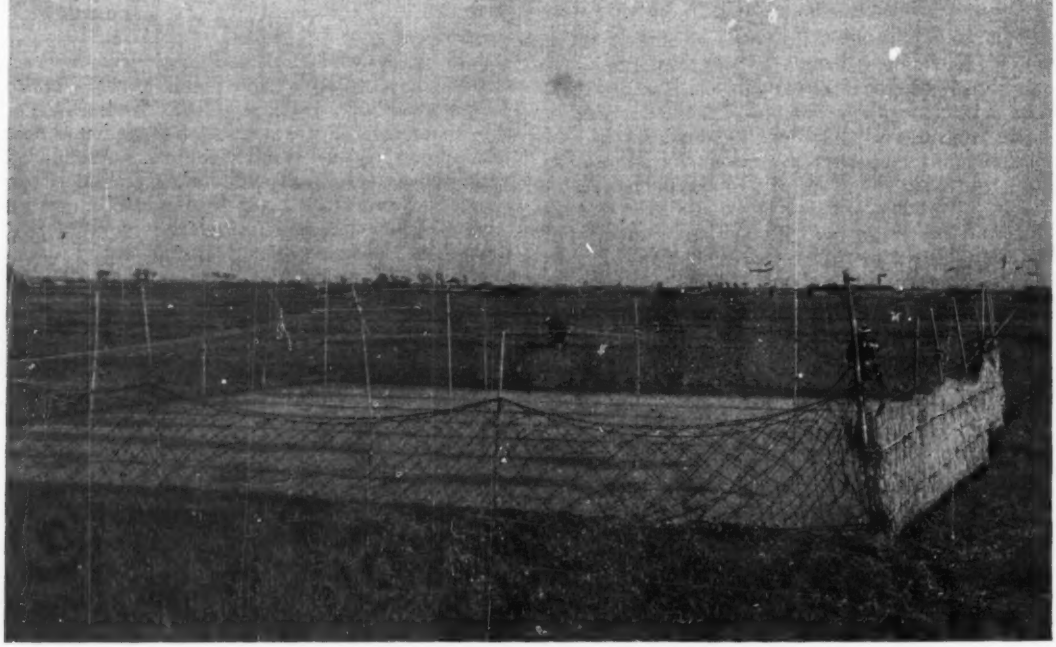


Fig. 1. The use of nets to protect a rice seedbed from damage by herons and egrets

largely with the individual. Although there are governmental agencies to offer advice, there is no centralized agency to carry out the control measures.

Several mechanical devices are employed to scare the birds, the most effective of which is a small homemade carbide cannon. A short length of bamboo three to five inches in diameter is hollowed out except for one nodal wall at the base. Near this wall a small hole is drilled. A lump of carbide dropped into the muzzle of the cannon with a little water creates sufficient gas to be fired by a lighted match held at the small hole. The resulting explosion drives sparrows and other birds from the adjacent fields. From dawn until about two hours after sunrise the cannoneer walks around his fields firing this weapon. The process is repeated morning and evening until the grain is harvested. This method gives good control at a very low cost, for a few lumps of carbide will last all morning or evening.

The use of nets about small paddies is also effective. Early in the spring seedbeds of rice are protected from trampling by egrets and herons by surrounding or covering the seedbed with a coarse net. (Fig. 1). As the seedbeds are small, 50 to 100 feet square, this method is very effective. Later in the year when grain in the more extensive paddies has headed or reached maturity, nets may again be employed. The mesh of these nets is not small enough to catch small birds, but the movement of the net in the wind is meant to discourage them. Such nets are placed at intervals about the fields.

Mist netting in sparrow roosts reduces the flocks, thereby decreasing damage to nearby grainfields. This also results in a direct profit to the farmer since tree sparrows can be sold for food at a rate of about three cents apiece.

In addition some of the more commonly used frightening devices are as follows. Small windmills attached to tin cans with pebbles in them are placed on posts about the fields. Wind operates the vanes, and the revolving cans set up a continuous rattle. All kinds of bright objects are suspended from poles so that they blow in the breeze; discarded light bulbs, twisted strips of shiny metal that glitter as they spin, mirrors, cans, cloth, etc. Very natural-appearing scarecrows are made of straw adorned with clothing. One of the most interesting methods is the use of kites. Two poles are set up about fifteen feet apart and a bright colored kite, usually with the fierce face of a demon, is suspended between them on a taut string. When the wind blows, the kites bound up and down in a menacing manner (Fig. 2).

Since female farm labor is cheaper than that of males, a farmer may detail his daughters to stay in the fields when the birds are feeding and to drive the birds away by clapping their hands or beating on cans.

Crows usually present individual problems of con-

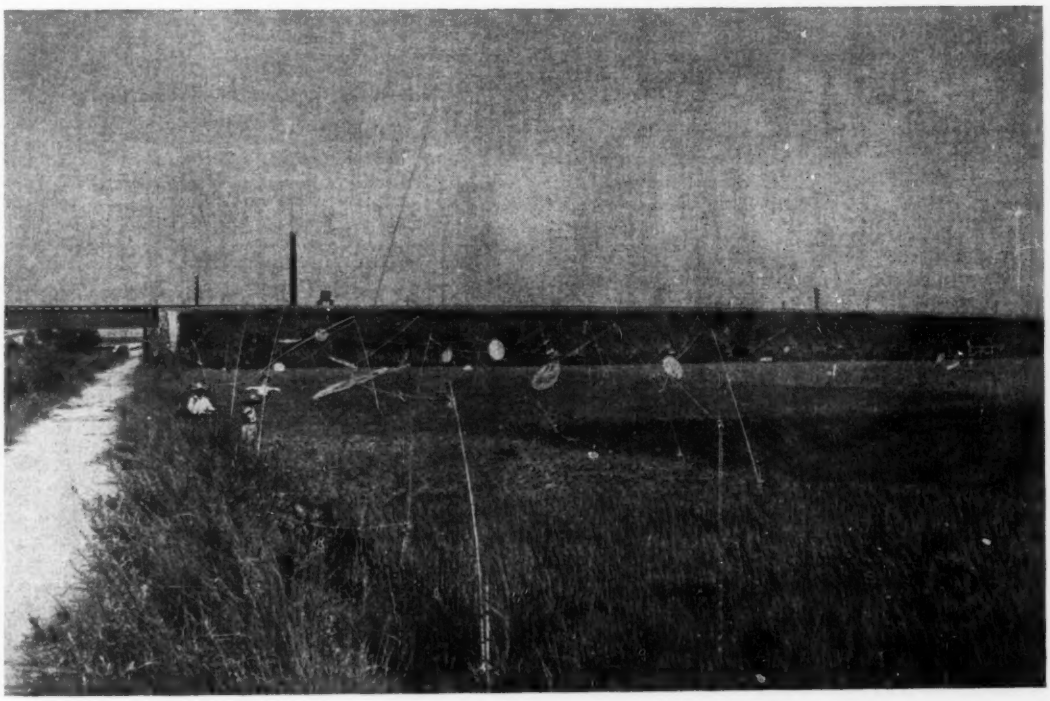


Fig. 2 The use of kites to protect grain from attack by tree sparrows

trol and are treated as such. Their nests are discovered and destroyed, or, if guns are available, the culprit crows are shot. A dead crow swinging from a string tied to a bamboo pole in a field is thought to discourage further depredation until the victim becomes a dried husk of feathers. If crows are damaging drying fish, fruit, or other products at processing plants, the foods are usually protected by nets. In general, however, crows are tolerated because most of their food is organic waste or offal and they help to keep the countryside clean.

As often happens when a man is confronted with the vexities of life, the Japanese farmer turns to his gods for aid. Prayers are offered for a good crop from the first turning of the soil. Aside from silent prayer, the physical manifestations of prayer are manifold. Papier-maché images of the protective Buddhist patron saint Daruma (Fig. 3) are often placed on poles in the field. Prayer boards to the rice god, whose messenger is the fox, are found in many fields. Other fields have before them strands of twisted straw rope adorned with prayer papers. The farmer may also pray for a good crop before his home shrine or at the local Shinto shrine or Buddhist temple.

The methods of bird control as listed here may appear primitive to the North American, but many of them have genuine value. They keep birds away from grain and reduce losses, they are adaptable to small fields, and they are not expensive.

Fig. 3. Image of Daruma, a Buddhist patron saint, placed in rice field to protect the grain

Received for publication February 15, 1956.

## TWO MARKING DEVICES FOR LARGE LAND MAMMALS

*Richard D. Taber, Anton de Vos, and Margaret Altmann*

Museum of Vertebrate Zoology, University of California, Berkeley,; Ontario Agricultural College, Guelph, Ontario; and Jackson Hole Biological Research Station, Moran, Wyoming

In the course of attempts to mark moose (*Alces americanus*) for field identification, the authors have developed two devices that can be used to deposit paint or dye on any large mammal using a definite trail.

In the marker used in Ontario (by de Vos) the trigger mechanism is a rat trap; this is fastened to a board above a trail, where it passes between two trees. The trip wire passes from the pan laterally to a tree, down the tree trunk and then across the trail at the height of the animal's shoulder. A razor blade is brazed to the striking-arm of the rat trap. A plastic bag full of coloring matter is suspended nearby. When the trap is sprung, the blade slashes the bag and the coloring matter showers down on the moose (Fig. 1). Care should be taken that the trip wire is too high to be sprung by mammals that it is not desired to mark. It has been noted that black bears (*Ursus americanus*) often molest and damage this device.

Another marking contraption used for moose (by Altmann and Taber) is also set along a trail. It consists of an arm about four feet long, pivoted in the middle. This is located so that, when horizontal, one arm will reach a little over halfway across the trail, at the height of the intended subject's shoulder. A container full of coloring matter (a hollow rubber ball with a section removed was successful) is fast-

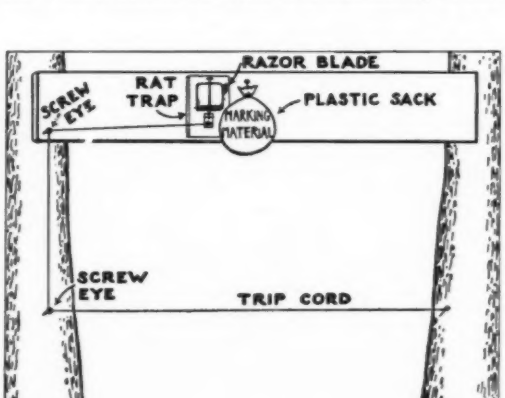



Fig. 1. The Ontario marking device

ened tc the upper end of the arm. A trip wire passes across the trail, through a screw eye behind the lower end of one arm, and forward again to loop around the lower end of the arm (Fig. 2). The pressure of the passing moose on the trip wire pulls the lower arm back and the upper arm deposits the coloring matter over its back or shoulders.

Paint, when used in the quantities which these devices put on the animal, causes the hair to mat and fall out. Fur dyes, especially if mixed with hydrogen peroxide, would probably be much more successful for animals with lighter pelage, such as elk (*Cervus canadensis*), deer (*Odocoileus* sp.), sheep (*Ovis* sp.), or goats (*Oreamnos americanus*). For a dark-coated mammal, such as a moose or black bear, there does not seem at present to be any suitable marking substance short of a depilatory.

Received for publication May 18, 1956.

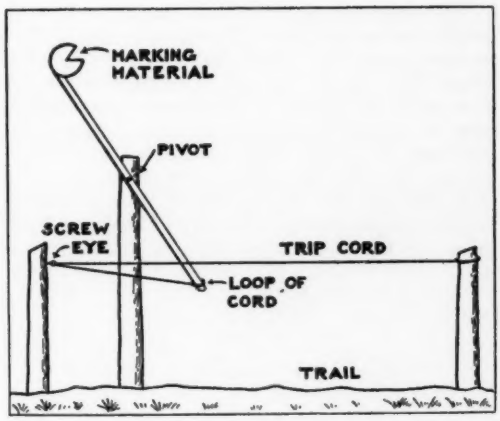



Fig. 2. The Wyoming marking device

# AN OBSERVATION CONCERNING THE VALIDITY OF COOT BROOD COUNTS

*Gordon W. Gullion*

Nevada Fish and Game Commission, Elko

The recent interest in productivity studies of the American Coot (*Fulica americana*) (*cf.* Kiel and Hawkins, Trans. N. Amer. Wildl. Conf., 18:311-322, 1953; Hunt and Naylor, Calif. Fish and Game, 41:295-314, 1955) make a note of caution imperative concerning the evaluation of nesting success and brood survival as determined by counts of broods less than three to four weeks old.

TABLE 1. — TWO SERIES OF BROOD COUNTS AT JEWEL LAKE, CONTRA COSTA COUNTY, CALIFORNIA, IN 1949 (TOTAL NUMBER IMMATURES FLEDGED IN "NORTH BROOD," 6; IN "SOUTH BROOD," 7)

| Date | North Brood With ♂ | North Brood With ♀ | North Brood Without ♂ | North Brood Without ♀ | North Brood Without Adults | South Brood With ♂ | South Brood With ♀ | South Brood Without ♂ | South Brood Without ♀ | South Brood Without Adults |
|---|---|---|---|---|---|---|---|---|---|---|
| April 30[1] | 8 | — | — | — | | | | | | |
| May 1 | — | — | 8 | — | | | | | | |
| May 1 | — | 7 | — | — | | | | | | |
| May 6 | 4 | — | — | — | | | | | | |
| May 8[2] | — | 2 | 2-3 | — | | 8 | — | — | — | |
| May 8 | — | 2 | 2 | — | | 7 | — | — | — | |
| May 8 | — | 3 | — | 1 | | — | 1 | — | — | |
| May 14 | — | 2 | — | — | | — | 1 | — | — | |
| May 14 | 2 | — | — | 3 | | 6 | — | — | — | |
| May 14 | — | 3 | — | — | | — | — | — | 1 | |
| May 14 | — | — | 3 | — | | — | — | 4 | — | |
| May 14 | | | | | | — | 2 | — | — | |
| May 14 | | | | | | — | — | — | 1 | |
| May 21 | — | 1 | 1 | 1 | | — | — | 2 | — | |
| May 21 | — | 2 | — | — | | 6 | — | — | — | |
| May 21 | — | 1 | — | — | | | | | | |
| May 21 | — | 2 | 2 | — | | | | | | |
| May 21 | — | 2 | 2 | 1 | | | | | | |
| May 21 | — | — | — | 4 | | | | | | |

| Date | North Brood With ♂ | North Brood With ♀ | North Brood Without ♂ | North Brood Without ♀ | North Brood Without Adults | South Brood With ♂ | South Brood With ♀ | South Brood Without ♂ | South Brood Without ♀ | South Brood Without Adults |
|---|---|---|---|---|---|---|---|---|---|---|
| May 21 | — | 1 | 5 | — | | | | | | |
| May 28 | 5 | — | — | — | | 5 | — | — | — | |
| May 28 | — | — | — | 2 | | 5 | — | — | — | |
| June 4 | 5 | — | — | — | | — | — | — | 7 | |
| June 5 | 5 | — | — | — | | | | | | |
| June 20 | — | — | — | 5 | | — | — | — | 4 | |
| June 20 | — | — | — | 6 | | — | — | — | 7 | |
| June 20 | — | — | — | 6 | | | | | | |
| June 20 | — | — | 6 | — | | | | | | |
| June 21 | | | | | | — | — | — | 5 | |
| June 21 | | | | | | — | — | — | 6 | |
| June 23 | | | | | | — | — | — | 4 | |
| June 24 | — | — | — | 3 | | | | | | |
| June 24 | — | — | 4 | — | | | | | | |
| June 26 | — | — | — | 3 | | — | — | — | 4 | |
| June 26 | | | | | | — | 6 | — | — | |
| June 26 | | | | | | — | — | — | 6 | |
| July 1[3] | — | — | — | 5 | | | | | | |
| July 2 | — | — | — | 5 | | | | | | |

[1] First north brood hatching.

[2] First south brood hatching.

[3] Second north brood hatching—after that date it became increasingly difficult to distinguish between members of the two older broods.

The tendency of the parent coots to split up broods and to feed them in different parts of their territory generally precludes reliable counts of broods less than 25 days old. To obtain any degree of accuracy in counts of young broods, the observer must be familiar with coot territorial behavior and the limits of each territory concerned (*cf.* Gullion, Condor, 55:169-186, 1953). Both parents must be seen and a count made of the young with them. Even then the count for the first three weeks is likely to run under 70 per cent of actual brood size, as shown in Table 1, and the chances are good that a complete count will never be obtained unless the area is checked for several hours daily for a week or so. It was noted in studies in western California (Gullion, Auk, 71:391, 1954) that frequently several young coots may be left unattended in the safety of dense cover while the parents separately forage with one or two young in widely separated parts of their territory.

Received for publication November 14, 1955.

# THE ARTIFICIAL ROOST—AN AID IN POPULATION STUDIES

*V. L. Yadon*

Oregon Cooperative Wildlife Research Unit

The artificial roost was used to determine covey size of valley quail, *Lophortyx californica californica* (Shaw), in the Madras Area of central Oregon during 1952 and 1953. Such gratifying results were obtained that the method is presented for further study.

On the study area, 6 artificial roosts were constructed similar to those described by Macgregor in California (Calif. Fish and Game, 36:316-319. 1950). Slight improvisions were made in order to utilize materials at hand. Salvaged boiler tubing was used for the legs of the table-like structure, and discarded sheep or hogwire netting was used to support a juniper brush pile. The roosts were constructed with no cost other than that of time and labor.

In the fall and winter, quail used the artificial roosts heavily. Coveys of 20 to 40 quail moved to the roosts without apparent hesitation. Later, the numbers were increased by other quail that moved into the areas. The quail returned each night to the artificial roosts instead of changing roosting trees frequently as was their usual custom. Even quail in very brushy areas preferred the artificial roosts. The few individual birds that apparently were not attracted to the roosts were those that used abandoned magpie (*Pica pica*) nests in juniper trees as roosting sites.

Groups of birds were observed in the late afternoon as they moved to the artificial roost location. Here they usually continued their evening feeding until just after sundown. The quail were then counted as they flew in groups of 2 and 3 into the artificial roosts. The entire evening activity usually lasted less than half an hour. At nesting time, when the birds were not in coveys, the roosts were not used.

As in every census method there were some complications. If the quail had been disturbed prior to roosting, the entire covey might fly into the roost at once. Very large coveys were not too easily counted because they took longer to settle. Small groups from the large coveys often returned to the ground to feed briefly in the immediate vicinity of the roost.

In the winter of 1954, large winter concentrations exceeding 200 birds were using three of the artificial roosts. Censusing was more difficult, but was more than 95 per cent accurate. Repeated counts on successive evenings increased the accuracy.

The attraction of the quail for the artificial roosts was possibly due to the fact that mammalian predation at night was eliminated or at least made negligible by the metal legs of the structures. The brush pile acted as a shelter against moisture, and enabled the quail to huddle together.

It was found that artificial roosts, to be effective, had to be more attractive to the quail than the existing nocturnal cover. The more brush piled on them, the better. The roosts had to be maintained each year by adding more brush or some other material that the birds could get under and thus be sheltered. Such materials as straw and wood paneling were used effectively in the Madras Area. The added material did not frighten or cause the quail any confusion that could be observed. If anything, the addition made the roosts more acceptable.

Evening appeared to be the most satisfactory time to make accurate counts of quail mainly because the birds moved into the shelters slowly. Morning counts were possible, but often the entire covey would fly from the roost in one complete evacuation. When this happened, an accurate count was impossible.

Contribution from the Oregon Cooperative Wildlife Research Unit: Agricultural Research Foundation, U.S. Fish and Wildlife Service, Wildlife Management Institute, Oregon State Game Commission. and Oregon State College cooperating; Arthur S. Einarsen, leader.

Received for publication January 4, 1956.

# A TECHNIQUE FOR CLOSING GATES ON BIG-GAME LIVE TRAPS BY REMOTE CONTROL

*Lawson G. Sugden*

British Columbia Game Department, Williams Lake, B. C.

While constructing a live trap for capturing bighorn sheep (*Ovis canadensis*) near Williams Lake, British Columbia, there arose the problem of closing two swinging 16 ft. x 9 ft. drop gates simultaneously from a distance exceeding 400 yards. Mechanical trips, while effective under certain conditions, were considered to require too much equipment in the area frequented by the sheep. Devices of this nature usually entail the erection of a series of posts upon which a line is strung. In addition, it would be difficult to trip two gates simultaneously a distance of more than 200 yards apart by mechanical means. Mr. Douglas Stevenson of Williams Lake suggested to the author the use of explosives as a means of tripping the gates.

The framework of the gates was made of one-inch galvanized pipe with weld connections. The gates were hinged on 7/8-inch round iron threaded through the pipe (Fig. 1). Upon dropping, the gates

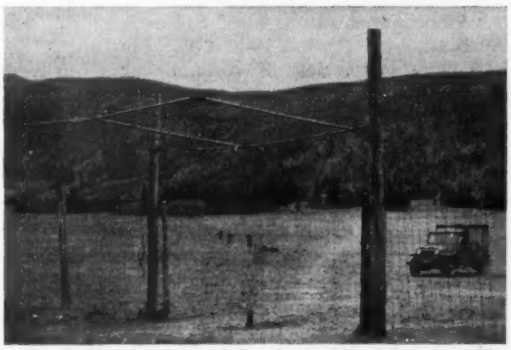


Fig. 1. The gate suspended and wired for detonation. The blasting machine was operated from a tree clump behind the truck.

were secured at each corner by spring catches constructed of 2-in. x 3/16-in. flat iron (Fig. 2).

Each gate was suspended by a single 3/8-inch rope. Two electrical detonating caps were taped on opposite sides of each rope and wired to a single circuit connecting both gates (Fig. 3). The circuit, consisting of No. 14 insulated wires, was stretched over the ground a distance of 600 yards to a point that offered full view of the trap and surroundings, and that could be approached undetected by sheep in the vicinity. The wires were fastened to the ground with large staples cut from No. 9 telephone wire and anchored at 100-yard intervals to stakes. Had a sufficient number of trees been present, the wires could have been strung on these.

The caps were exploded by means of a 50-cap blasting machine. Depending upon the distance of the detonator from the caps and the number of caps utilized, several gates could thus be tripped simultaneously from a single point. Test shots were made before trapping commenced to check the circuit and gate catches. A galvanometer can be used at any time to check the circuit.

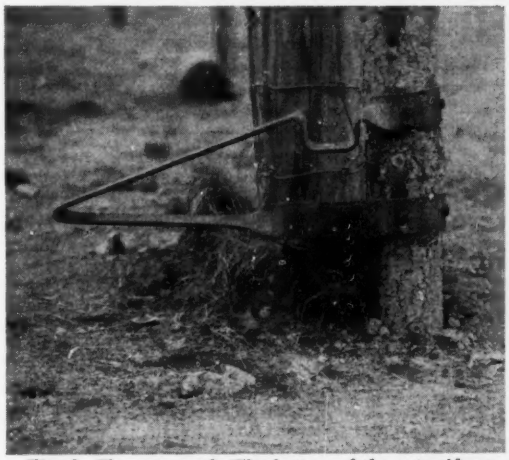


Fig. 2. The gate catch. The bottom of the gate rides up the incline plane and springs into the notch.

Animals, whether inside the trap or out, jumped away from the sound of the explosion and thus eliminated any chance of jamming the rapidly closing gates.

Received for publication July 26, 1955.

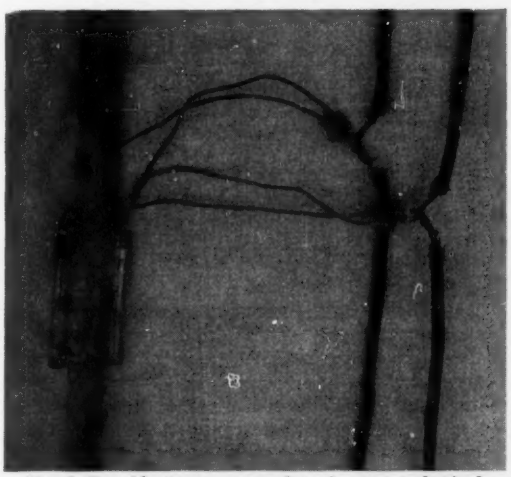


Fig. 3 Two blasting caps taped to the rope and wired to the circuit. All connections should be taped.

# INDEX FOR VOLUME 20


**Age ratios and age groups**
bob-white, 241
deer, white-tailed, 289, 301
marten, 267
Aldous, Clarence M. Conducting deer studies with the use of a helicopter, 327
see also Robinette, W. Leslie, 75
Alewife, introduction in Maine, 396
Allan, Philip F. A system for evaluating coastal marshes as duck winter range, 247
Allen, Durward L. Book reviews by, 196, 323
Pheasant in North America (reviewed), 447
Altmann, Margaret, see Taber, Richard D., 464
Antelope, pronghorn
identification by precipitin reaction, 169
mortality in winter, 164
Ash, J. S., see Blank, T. H., 328
Atkeson, Thomas Z. Incidence of crippling loss in steel trapping, 323
Atwood, Earl L. Validity of mail survey data on bagged waterfowl, 1

Badger predation on goose nests, 407
Bailey, R. Wayne. Sex determination of adult wild turkeys by means of dropping configuration, 220
Baldpate
nesting study, 282, 346
sex ratios, 385
**Banding returns**
grouse, sharp-tailed, 50
pheasants, 454
woodcock, 420
Bass
largemouth
blood oxygen and temperature, 56
status, Minn. lakes, 316
smallmouth
production factors, 353
white
status, Minn. lakes, 316
yellow
growth computation, 23
Beaver
die-off in Michigan, 184
predation by bobcat, 199
transplantation behind Urals, 69
Beeson, Kenneth C., see Smith, Frank H., 359
**Behavior**
courtship, blue-winged teal, 33
desert game at water tank, 368
geese in nesting concentration, 415
homing, 293
nest defecation, 244
territory, blue-winged teal, 33
Berg, Paul F. A study of waterfowl broods in eastern Montana with special reference to movements and the relationship of reservoir fencing to production, 253
Bizeau, Elwood G., see Steel, Paul E., 279
Blank, T. H. and J. S. Ash. Marker for game birds, 328
Bluegill
predation by pike on, 118
status, Seney Refuge, Michigan, 116
Minn. lakes, 316
variance of body length, 26
Bobcat, food habits, Maine, 199
Bohl, Wayne H. Experiments in locating wild chukar partridges by use of recorded calls, 83
Brambling, 462
Brandy, John, see Kitts, W. D., 212
Breckenridge, W. J. Nesting study of wood ducks, 16
Buffalofish, status, Minn. lakes, 316
Bufflehead
*Leucocytozoon* in, 209
sex ratios, 385
Bullhead
black, status, Minn. lakes, 316
brown
predation by pike on, 118
status, Seney Refuge, Michigan, 116
Minnesota lakes, 316
vulnerability to kingfishers, 179
yellow, status, Minn. lakes, 316
Burbutis, Paul P., and Robert E. Mangold. A study of the fleas of cottontail rabbits in New Jersey, 217
Burdick, Milton E. and Edwin L. Cooper. Growth rate, survival, and harvest of fingerling rainbow trout planted in Weber Lake, Wisconsin, 233
Buss, Irven O., see Johnsgard, Paul A., 384
Byrd, M. A. Relation of ecological succession to farm game in Cumberland County in the Virginia Piedmont, 188

Campbell, Howard, and Levon Lee. Notes on the sex ratio of Gambel's and scaled quail in New Mexico, 93
Canvas-back
nesting study, 282, 346
sex ratios, 385
Capercaillie, transplantations, Europe, 69
Caribou, fluctuations and snow depth, 161
Carlander, Kenneth D., see Whitney, Richard R., 21
Carp
response to phosphorus, 318
status, Minn. lakes, 316
Chamberlain, E. B., Jr., see Grice, G. D., Jr., 330
Chapman, Floyd B. Some behavior characteristics of mammals useful in management, 293
Chipmunk
predation by bobcat, 199
subjected to fibroma virus, 87
Christian, John J., see Davis, David E., 378
Chub, creek
status, Seney Refuge, Michigan, 116
vulnerability to kingfishers, 179

Cleary, Robert E. Observations on factors affecting smallmouth bass production in Iowa, 353
Cod, predation by fur seal, 215
Coleman, I. A., see Klonglan, E. D., 173
Cooper, Edwin L., see Burdick, Milton E., 233
Coot, American
  brood counts, validity of, 465
  nesting density, Iowa, 33
Cope, Oliver B., see Laakso, Martin, 138
Cowan, I. McT., see Kitts, W. D., 212
Craighead, John J. and Dwight S. Stockstad. A colored neckband for marking birds, 331
Crappy, black, status, Minn. lakes, 316
**Creel census**
  Iowa, 357
  Maine, 392
  Wisconsin, 234
**Crippling losses**
  bob-white, 241
  steel trapping, 323
Crispens, Charles G., Jr. Prolactin: an evaluation of its use in ring-necked pheasant propagation, 453
  see also Semones, Vernon D., 200
Crow
  crop damage, Japan, 462
  predation on goose nests, 407
Dace
  blacknose
    status, Seney Refuge, Michigan, 116
    vulnerability to kingfishers, 179
  longnose
    vulnerability to kingfishers, 179
  redbelly
    predation by pike on, 118
    status, Seney Refuge, Michigan, 116
Dalke, Paul D., see Steel, Paul E., 279
Darters
  predation by pike on, 118
  status, Seney Refuge, Michigan, 116
  vulnerability to kingfishers, 179
Dasmann, Raymond F. and Richard D. Taber. Determining structure in Columbian black-tailed deer populations, 78
Davis, David E. and John J. Christian. Changes in Norway rat populations induced by introduction of rats, 378
Davis, David E. and John T. Emlen. Differential trapability of rats according to size and sex, 326
Davis, Earle M., Jr., see Gysel, Leslie W., 451
Deer, general
  census methods
    carcasses, 75
    general, 70, 327
  chemical composition of herbage, 359
  fluctuations and snow depth, 161
  mountain maple management, 434
Deer, species
  black-tailed
    age criteria, 78
    milk composition of, 212
    postnatal mortality, 214
    sex criteria, 78
  central maral, hybridization with wapati, 69
  fallow
    history in eastern Poland, 68
    introduced, Texas, 460
  mule
    behavior at water tank, 370
    identification by precipitin reaction, 169
    introduced, Texas, 461
  red, history in eastern Poland, 68
  roe, history in eastern Poland, 68
  white-tailed
    age classes, 290, 301
    homing, 294
    hunting study, 297
    introduced, Texas, 461
    nutrient requirements, 221
    populations, N. Carolina areas, 360
    predation by bobcat, 199
    productivity, 289, 301
    regional differences, 286
    sex ratio, 301
    weights, 289, 300
**Densities**
  doves, mourning, 428
  fish, Minn. lakes, 316
  quail, bob-white, 241
  trout, rainbow, 234
Denyes, H. Arliss and Jeanne M. Joseph. Relationships between temperature and blood oxygen in the largemouth bass, 56
de Vos, Antoon. Book review by, 92
  see also Taber, Richard D., 464
**Diseases and parasites**
  blood parasites in ducks, 207
  *Eimeria environ*, 459
  fibroma in cottontails, 85
  filariae in Canada geese, 89
  fleas of cottontail, 217
  myxoma virus in
    cottontails, 87
    European rabbit, 87
  ticks, beaver, muskrat, 186
  tularemia in beaver, 184
Dorney, Robert S. and Helmer M. Mattison. Trapping techniques for ruffed grouse, 47
Dove
  mourning
    behavior at water tank, 375
    density, Georgia, 428
    productivity, Georgia, 428
    technique bursal inspection, 94
  white-winged, behavior at water tank, 374
**Drainage**
  compensation by large marshes, 349
  effect on teal nesting, 44
Duck
  black, blood parasites in, 208
  ring-necked, sex ratios, 385
  ruddy
    nesting, N. Dakota, 346
    nesting density, Iowa, 33

nesting study, 282
sex ratios, 385
wood
blood parasites in, 208
incubation periods, 16
Ducks
blood parasites in, 207
hunting-kill estimates, 1
trapping with cannon-type net, 201
*see also* waterfowl
Durant, A. J. Impaction and pressure necrosis in Canada geese due to eating dry hulled soybeans, 399

Eberhardt, Lee, and Robert C. Van Etten. Evaluation of the pellet group count as a deer census method, 70
Ecke, Dean H. Minimum lethal temperature for the cottontail parasite *Eimeria environ*, 459
**Education,** television used in, 456
Edwards, R. Y. Snow depths and ungulate abundance in the mountains of western Canada, 159
see also Ritcey, R. W., 324
Eipper, Alfred W. Differences in vulnerability of the prey of nesting kingfishers, 177
Elder, James B. Watering patterns of some desert game animals, 368
Elk, see wapiti
Emlen, John T., see Davis, D. E., 326
Erickson, Arnold B., see Krefting, L. W., 297
Exotic introductions, see Transplantation

Fallfish, vulnerability to kingfishers, 179
Fantail, status, Seney Refuge, Michigan, 116
Fay, L. D., see Lawrence, William H., 184
Findley, James S. Comments on the winter food of red foxes in South Dakota, 216
**Fire,** effect on
mountain caribou, 166
teal nesting, 39
Fish
growth computations, 21
sand, predation by fur seal, 215
Fisher, James. Wild America (reviewed), 323
Fitch, Frank W., Jr., see Rosene, Walter, Jr., 205
**Food**
bicolor lespedeza, bob-white, 108, 239
bobcat, 199
bob-white, 125
fox, red, 216
pike, 118
sample size in analyses of, 64
seal, fur, 214
trout, rainbow, 238
turkey, wild, 132
Forward, William R., see Hammond, M. C., 243
Fox
gray
age determination, 210
crippling loss, 324
polar, transplantation, 69
red
age determination, 210
crippling loss, 324
dens on teal study area, 41
food habits, 216
review of study by T. G. Scott and W. D. Klimstra, 196
Foye, Robert E. Reclamation of potential trout ponds in Maine, 389
French, C. E., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. Nutrient requirements for growth and antler development in the white-tailed deer, 221
Frogs, predation by pike on, 118
Frye, O. Earle, Jr., see Laessle, Albert M., 125

Gadwall
nesting study, 282, 346
population, Colorado, 445
sex ratios, 385
Gashwiler, Jay S., see Robinette, W. Leslie, 75
Gehrken, George A. Shrub lespedeza as a quail management plant in southeastern Virginia, 239
Geis, Mary Barraclough. Productivity of Canada geese in the Flathead Valley, Montana, 409
Gilbert, Douglas L. Television as a wildlife-education medium, 456
Gill, John. Regional differences in size and productivity of deer in West Virginia, 286
Glover, Fred A. Nesting and production of the blue-winged teal . . . in northwest Iowa, 28
Goats, mountain, fluctuations, British Columbia, 162
Golden-eye
American, *Microfilaria* in, 209
Barrow's, sex ratios, 385
Goose, Canada
filariae in, 89
impaction of food in, 399
mortality in Florida, 330
neck band for, 332
population build up, 345
pressure necrosis, 399
productivity in Montana, 409
trapping with cannon-type net, 201
Gordon, Seth. Obituary of Kenneth A. Reid, 446
Graham, S. A., see Lawrence, William H., 184
Graybill, Franklin, see Hanson, William R., 64
**Grazing**
control of, 44
effect on teal nest success, 41
Greenfinch, 462
Greenwalt, Lynn A., see Sowls, Lyle K., 215
Grice, G. D., Jr., E. L. Tyson, and E. B. Chamberlain, Jr. An unexplained mortality of Canada geese in North Florida, 330
Grieb, Jack R. and Mitchell G. Sheldon. Radio-controlled firing device for the cannon-net trap, 203
Grouse
black, transplantation, 69
hazel, transplantation, 69
ruffed
predation by bobcat, 199

trapping techniques, 45
willow, see Ptarmigan
**Growth studies,** trout, rainbow, 233
Gullion, Gordon W. An observation concerning the validity of coot brood counts, 465
Gutermuth, C. R. Obituary of Charles H. Hopkins, 320
Gysel, Leslie W. and Earle M. Davis, Jr. A simple automatic photographic unit for wildlife research, 451

Halloran, Arthur F. and Julian A. Howard. Aransas Refuge wildlife introductions, 460
Hammond, M. C. and W. R. Forward. Experiments on causes of duck nest predation, 243
Hammond, M. C. and G. E. Mann. Waterfowl nesting islands, 345
Hansen, H. L., see Krefting, L. W., 434
Hanson, Harold C., Norman D. Levine, and Sidney Kantor. Filariae in a wintering flock of Canada geese, 89
Hanson, William R. and Franklin Graybill. Sample size in food-habits analyses, 64
Hare
European, transplantation in Russia, 69
snowshoe, predation by bobcat, 199
Haugen, Arnold O., see Sullivan, Edward G., 210
Hendrickson, George O., see Linder, Raymond L., 96
see also Kozicky, Edward L., 97
Herman, Carlton M., Lawrence Kilham, and Oscar Warbach. Incidence of Shope's rabbit fibroma in cottontails at the Patuxent Research Refuge, 85
Hewitt, Oliver H., editor's note, 332
Hochbaum, H. Albert. Book review by, 195
Hog, feral, introduced, Texas, 461
Hopkins, Charles H., obituary of, 320
Howard, Julian A., see Halloran, Arthur F., 460
**Hunting**
kill estimates, waterfowl, 1
quail, bob-white, 241
special deer seasons, 297

Ingram, R. H., see French, C. E., 221
Introduction, see Transplantation.

Jackrabbit, white-tailed
predation on, red fox, 216
Javelina
behavior, 372
utilization of water tank, 369
Jay, blue, predation by bobcat, 199
Jessen, Raymond J., see Edward L. Kozicky, 97
Johnsgard, Paul A. and Irven O. Buss. Waterfowl sex ratios during spring in Washington and their interpretation, 384
Jones, Dale A., see Robinette, W. Leslie, 75
Jones, Gardiner F., obituary of, 320
Joseph, Jeanne M., see Denyea, H. Arliss, 56

Kantor, Sidney, see Hanson, Harold C., 89
Keiss, R. W. and S. M. Morrison. Identification of Colorado big-game animals by the precipitin reaction, 169
Kenyon, Karl W. Food of fur seals taken on St. Paul Island, Alaska, 1954, 214
Kilham, Lawrence, see Herman, Carlton M., 85
Kingfisher, belted, food habits of, 177
Kitts, W. D., I. McT. Cowan, John Brandy, and A. J. Wood. The immediate postnatal growth in the Columbian black-tailed deer in relation to the composition of the milk of the doe, 212
Klimstra, Willard D., see Scott, Thomas G., 196
Klonglan, E. D., I. A. Coleman and E. L. Kozicky. A pheasant nest-activity recording instrument, 173
Kozicky, Edward L., Raymond J. Jessen, and George O. Hendrickson. Estimation of fall quail populations in Iowa, 97
see also Klonglan, E. D., 173
Krefting, Laurits W. and Arnold B. Erickson. Results of a special deer hunt on the Mud Lake National Wildlife Refuge, Minnesota, 297
Krefting, L. W., H. L. Hansen, and M. H. Stenlund. Stimulating regrowth of mountain maple for deer browse by herbicides, cutting, and fire, 434

Laakso, Martin and Oliver B. Cope. Age determination in Yellowstone cutthroat trout by the scale method, 138
Laessle, Albert M. and O. Earle Frye, Jr. A food study of the Florida bob-white, 125
Lagler, Karl F. The pike, *Esox lucius* Linnaeus, in relation to waterfowl on the Seney National Wildlife Refuge, Michigan, 114
Latham, Roger M. Midwinter courtship flights of woodcock in Delaware, 209
Lauckhart, J. Burton. Obituary of Charles F. Jones, 320
Lawrence, William H., L. D. Fay, and S. A. Graham. A report on the beaver die-off in Michigan, 184
Lee, Levon, see Campbell, Howard, 93
Levine, Norman D., see Hanson, Harold C., 89
**Limnological studies**
Minnesota surface waters, 303
pools, Seney Refuge, 115
Lindemann, W. Transplantation of game in Europe and Asia, 68
Linder, Raymond L. and George O. Hendrickson. A door catch for the wooden box trap, 96
Lowe, Jack I. Breeding density and productivity of mourning doves on a county-wide basis in Georgia, 428

Magpie, relation to nesting geese, 415
Magruder, N. D., see French, C. E., 221
Mallard
brood data, 284
egg data, 283
movement, brood, 261
nest sites, 282
nest success, 282
nesting
Colorado, 445
Iowa, 33

N. Dakota, 346
predation by pike, 118
production, 445
sex ratios, 385
**Management**
bicolor lespedeza, 104, 239
drainage, 44
fencing reservoirs, 253
grazing, 44
hunting dates, 45
mice on cutovers, 405
mountain maple for deer browse, 434
predators, 45
soybean fields near refuges, 404
trapping pressure, marten, 267
water levels, 44
waterfowl nesting islands, 345
Mangold, Robert E., see Burbutis, Paul P., 217
Mann, G. E., see Hammond, M.C., 345
Marten
age groups, 267
management of, 267
sex ratio, 267
Matthews, G. V. T. Bird navigation (reviewed), 194
Mattison, Helmer M., see Dorney, Robert S., 47
McClure, H. Elliott. Protecting grain fields in Japan from pilferage by birds, 462
McEwen, L. C., see French, C. E., 221
Merganser, common, sex ratios, 385
Mice
affected by slash burn, 405
predation by
bobcat, 199
pike, 118
red fox, 216
subjected to fibroma virus, 87
Mink
predation on
coots, 43
goose nests, 407
grebes, 43
teal nests, 40
transplantation in Russia, 69
Minnows
predation by pike on, 118
status, Seney Refuge, Michigan, 116
Moose
book review on, 92
functuations and snow depth, 161
marking device for, 464
tagging, 324
trapping, 324
Morrison, S. M., see Keiss, R. W., 169
**Mortality**
geese eating soybeans, 399
geese in Florida, 330
goslings in Montana, 417
mice caught in slash burn, 405
woodcock in Mass., 420
*see also* Predation
**Movement,** waterfowl broods, 253
Moyle, John B. Relationships between the chemistry of Minnesota surface waters and wildlife management, 303
Muddler, status, Seney Refuge, Michigan, 116
Mudminnow
predation by pike on, 118
status, Seney Refuge, Michigan, 116
Muskrat, transplantation, Europe, 69
**Nesting studies**
geese, Canada, 409
shoveller, 244
smallmouth bass, 353
teal, blue-winged, 28, 244
wood duck, 16
Nutria, transplantation, Russia, 69
**Nutrition,** deer, white-tailed, 221

Obituaries of
Hopkins, Charles H., 320
Jones, Gardiner F., 320
Reid, Kenneth A., 446
Weese, Asa Orrin, 322
Wheeler, James W., 321
Opossum
crippling loss, 324
subjected to fibroma virus, 87

Parasites, see Diseases and parasites
**Parasitism** on teal nests by pheasants, 42
Partridge
chukar, locating by recorded calls, 83
Hungarian, plastic marker for, 328
red-legged, plastic marker for, 330
Perch, yellow
predation by pike on, 118
status
Minnesota lakes, 316
Seney Refuge, Michigan, 116
Peterle, Tony J. Trapping techniques and banding returns for Michigan sharp-tailed grouse, 50
Peterson, Randolph L. North American moose (reviewed), 92
Peterson, Roger Tory. Wild America (reviewed), 323
Pheasant, ring-necked
incubation by male, 200
introduced, Texas, 461
nest-activity recorder, 173
parasitism by, teal nests, 42
plastic marker for, 330
predation by red fox, 216
prolactin in propagation, 453
Pig, feral, introduced, Texas, 461
Pike, northern
food, 118
relation to waterfowl, 114
status
Minnesota lakes, 316
Seney Refuge, Michigan, 116
Pintail
brood data, 284
egg data, 283

movement, brood, 261
nest sites, 282
nesting, N. Dakota, 346
nesting success, 282
sex ratios, 385
**Poisons,** in trout pond reclamation, 390
Porcupine, predation by bobcat, 199
**Predation**
absence of, at water tank, 377
duck nests, 243, 346
goose nests, 415
pike, 114
red foxes, 196
teal nests, 40
*see also* Food
Price, Walter E., see Smith, Frank H., 359
**Production**
bass, smallmouth, 353
deer, white-tailed, 286, 301
doves, mourning, 428
fish affected by water chemistry, 315
geese, Canada, 409
trout, rainbow, 234
waterfowl, 253, 279, 443
Ptarmigan
transplantation, Poland, 69
willow, age determination, 274
Pumpkinseed, status, Seney Refuge, Michigan, 116

Quail
bob-white
food of, Florida, 125
responses to bicolor lespedeza, 104, 239
response to plant succession, 188
subjected to fibroma virus, 87
technique, population estimates, 97
variables in age determination, 205
California
artificial roosts for, 466
census method for, 466
introduced, Texas, 461
Gambel's
behavior at water tank, 376
plastic marker for, 330
sex ratio, 93
trapping technique, 215
scaled
age criteria, 154
sex criteria, 154
sex ratio, 93
trapping technique, 215
Quick, Horace F. Effects of exploitation on a marten population, 267

Rabbit
cottontail
box trap for, 96
fibroma in, 85
fleas of, 217
predation on, red fox, 216
response to plant succession, 188
European, susceptibility to myxoma virus, 87
Raccoon
crippling loss, 324
predation on teal nests, 40
Raccoon-dog, transplantation, 69
**Range analysis,** waterfowl, 247
Rat, Norway
differential trapability, 326
population changes after introduction, 378
Raven, predation on goose nests, 407
Redhead
brood data, 284
egg data, 283
nest sites, 282
nesting density, Iowa, 33
nesting, N. Dakota, 346
nesting success, 282
sex ratios, 385
Redhorse, golden, status, Seney Refuge, Michigan, 116
Reid, Kenneth A. Obituary of, 446
Ritcey, R. W. and R. Y. Edwards. Trapping and tagging moose on winter range, 324
Robinette, W. Leslie, Dale A. Jones, Jay S. Gashwiler and C. M. Aldous. Further analysis of methods for censusing winter-lost deer, 75
Rosene, Walter, Jr. An appraisal of bicolor lespedeza in quail management, 104
and Frank W. Fitch, Jr. A comparative test of the investigator as a variable in aging quail, 205
Ruhl, H. D. Obituary of James W. Wheeler, 321

Sable, Kamchatka, transplantation, 69
Scaup, lesser
nesting, N. Dakota, 346
nesting study, 282
sex ratios, 385
Schemnitz, Sanford D. Wild turkey food habits in Florida, 132
Schorger, A. W. Book review by, 197
Scott, Thomas G. and Willard D. Klimstra. Red foxes and a declining prey population (reviewed), 196
Seals, fur, food of, 214
Sea-poacher, predation by fur seal, 215
Semones, Vernon D. and Charles G. Crispens, Jr. Three records of male Mongolian pheasants incubating clutches, 200
**Sex ratios**
deer, white-tailed, 301
marten, 267
quail
bob-white, 241
Gambel's 93
scaled, 93
teal, blue-winged, 33
waterfowl, 384
Sheep, bighorn, identification by precipitin reaction, 169
Sheep, mountain, fluctuations, British Columbia, 162
Sheepshead, status, Minn. lakes, 316
Sheldon, Mitchell G., see Grieb, Jack R., 203

Sheldon, William G. Annual survival of Massachusetts male woodcocks, 420
Shiner,
  blacknose
    predation by pike on, 118
    status, Seney Refuge, Michigan, 116
  common, vulnerability to kingfishers, 179
  golden
    predation by pike on, 118
    status, Seney Refuge, Michigan, 116
  mimic, status, Seney Refuge, Michigan, 116
Shoveller
  movement, brood, 261
  nesting data, 244, 282, 346
  sex ratios, 385
Shrew, predation by bobcat, 199
Skunk
  predation by bobcat, 199
  striped
    crippling loss, 324
    predation on
      goose nests, 407
      teal nests, 40
Smith, Frank H., Kenneth C. Beeson, and Walter E. Price. Chemical composition of herbage browsed by deer in two wildlife management areas, 359
Snake, garter, predation by pike on, 118
Sowls, Lyle K. and Lynn A. Greenwalt. Large traps for catching quail, 215
Sparrows, tree, damage to grain, 462
Squirrel
  flying
    predation by bobcat, 199
    subjected to fibroma virus, 87
  gray, leaf-nest theory, 263
  red, predation by bobcat, 199
  *Sciurus vulgaris*, transplantation in Russia, 69
Starling, gray, 462
Steel, Paul E., Paul D. Dalke, and Elwood G. Bizeau. Duck production at Gray's Lake, Idaho, 1949-1951, 279
Stenlund, M. H., see Krefting, L. W., 434
Stickleback
  predation by pike on, 118
  status, Seney Refuge, Michigan, 116
Stockstad, Dwight S., see Craighead, J. J., 331
Storer, Tracey I. and Lloyd P. Tevis, Jr. California grizzly (reviewed), 197
Sucker
  hog, vulnerability to kingfishers, 179
  white
    predation by pike on, 118
    response to phosphorus, 316
    status
      Seney Refuge, Michigan, 116
      Minn. lakes, 316
    vulnerability to kingfishers, 179
Sugden, Lawson G. A technique for closing gates on big-game live traps by remote control, 467
Sullivan, Edward G. and Arnold O. Haugen. Age determination of foxes by X-ray of forefeet, 210
**Survival,** trout, rainbow, 233
  *see also* Mortality
Sutton, George Miksch. Obituary of Asa Orrin Weese, 322
Swift, R. W., see French, C. E., 221
Swope, Harold M., see Yeager, Lee E., 442

Taber, Richard D., Anton de Vos, and Margaret Altmann. Two marking devices for large land mammals, 464
Taber, Richard D., see Dasmann, Raymond F., 78
Teal
  blue-winged
    blood parasites in, 209
    movement, brood, 261
    nest sites, 282
    nesting study, 28, 244, 282, 346, 445
    population level, 445
    production, 445
    sex ratios, 385
  cinnamon
    nesting study, 282
    population, Colorado, 445
    sex ratios, 385
  green-winged
    nest sites, 282
    sex ratios, 385
**Techniques**
  age determination
    black-tailed deer, 78
    foxes, 210
    ptarmigan, willow, 274
    quail, scaled, 154
    quail, bob-white, 205
    trout, cutthroat, 138
    waterfowl eggs, 112
  artificial roosts, quail, 466
  bursal inspection, mourning doves, 94
  census methods
    deer, 70, 327
    doves, 432
    quail, 466
    winter-lost deer, 75
  door catch, wooden box trap, 96
  field candler, waterfowl eggs, 111
  food-habits analyses, sample size in, 64
  growth computations, fish, 21
  helicopter, use of, 327
  identification by precipitin reaction, 169
  locating chukar partridge, 83
  marking devices, 218, 464
  nest-activity recording instrument, 173
  pellet-group count, 70
  photographing wildlife, 451
  plastic markers, 218, 328, 331
  population estimates, bob-white, 97
    bass, smallmouth, 257
  prolactin in pheasant propagation, 453
  protection of grain fields, 462
  reclamation of trout ponds, 389
  sex determination, 154
    deer, black-tailed, 78

quail, scaled, 154
turkey, wild, 220
stimulating regrowth for deer browse, 434
tally-counter holder, 198
television in wildlife education, 456
trapping
big game, 466
cannon-type net, 201, 203
moose, 325
quail, 215
ruffed grouse, 47
sharp-tailed grouse, 50
Tevis, Lloyd, Jr. Effect of a slash burn on forest mice, 405
*see also* Storer, Tracy I., 197

**Transplantation**
deer
fallow, 460
mule, 461
white-tailed, 461
game, in Europe and Asia, 68
hare, snowshoe, 295
hogs, feral, 461
parasites introduced by, 217
pheasants, ring-necked, 461
quail, Calif., in Texas, 461
rabbit, cottontail, 295
rats, Norway, 378
turkey, wild, 461

**Trapping**
crippling loss, 323
differential vulnerability to, 326
*see also* Techniques

Trout
brook
growth, 396
management of ponds for, 389
spawning, 397
status, Seney Refuge, Michigan, 116
vulnerability to kingfishers, 179
brown
food habits, Maine, 396
status, Seney Refuge, Michigan, 116
stocking, Maine, 392
vulnerability to kingfishers, 179
cutthroat
age criteria, 138
age-frequency distribution, 150
lake, response to alkalinity, 316
rainbow
growth rate, 233
harvest, 233
survival, 233
Tullibee, response to phosphorus, 316
Turkey, wild
food of, Florida, 132
introduced, Texas, 461
sex determination, 220
Turner, Lewis B. Improved technique in goose trapping with cannon-type net traps, 201
Turtles
box, subjected to fibroma virus, 87
snapping, predation on young teal, 43
Tyson, E. L., see Grice, G. D., Jr., 330

Uhlig, Hans G. A theory on leaf nests built by gray squirrels on Seneca State Forest, West Virginia, 263

Van Etten, Robert C., see Eberhardt, Lee, 70

Wagner, Frederic H. Book review by, 447
Walleye, yellow, status
Minnesota lakes, 316
Seney Refuge, Michigan, 116
Wallmo, O. C. Determination of sex and age of scaled quail, 154
Wapiti
fluctuations, British Columbia, 162
hybridization with central maral deer, 69
identification by precipitin reaction, 169
transplantation of, in Poland, 69
Warbach, Oscar, see Herman, Carlton M., 85
Waterfowl
field candler, eggs, 111
hunting-kill estimates, 1
nesting density, Iowa, 33
nesting islands, 345
production, 279, 442
relation to pike, 114
sex ratios, 384
Weasel, long-tailed
predation on teal nests, 41
subjected to fibroma virus, 87
Weeden, Robert B., see Westfall, Claude Z., 218
Weese, Asa Orrin. Obituary of, 322
**Weights,** deer, white-tailed, 289, 300
Weller, Milton W. A simple field candler for waterfowl eggs, 111
Westerskov, Kaj. Age determination and dating nesting events in the willow ptarmigan, 274
Westfall, Claude Z. Foods eaten by bobcats in Maine, 199
and Robert B. Welden. Plastic neck markers for woodcock, 218
Wheeler, James W. Obituary of, 321
Whitney, Richard R. and Kenneth D. Carlander. Interpretation of body-scale regression for computing body length of fish, 21
Widgeon, American. see Baldpate.
Wight, Howard M. A field technique for bursal inspection of mourning doves, 94
Wildlife Society, The
Reports of officers and committees, 333
Nominations for officers, 352
Wisent, history, eastern Poland, 68
Wood, A. J., see Kitts, W. D., 212
Woodchuck, subjected to fibroma virus, 87
Woodcock
courtship flights, midwinter, 209
plastic neck markers for, 218
survival of Mass. males, 420
Woodgerd, Wesley. A tally-counter holder, 198

Yadon, V. L. The artificial roost—an aid in population studies, 466
Yeager, L. E. and Harold M. Swope. . Waterfowl production during wet and dry years in north-central Colorado, 442
Yellow-legs, lesser, predation by pike on, 118

## EDITORIAL ACKNOWLEDGMENTS

Volume 20 of the Journal of Wildlife Management was the work of 160 contributors whose names appear in the index above. Less conspicuous but nevertheless vitally important to our publication were the consulting services freely rendered to the editor by 29 others during the past year: Lowell Adams (U.S. For. Serv.), P. F. Allan (S.C.S.), O. L. Austin, Jr. (U.S.A.F.), E. L. Cheatum (N.Y. Cons. Dept.), D. E. Davis (Johns Hopkins U.), Joseph Dell (N.Y. Cons. Dept.), W. H. Elder (U. Mo.), Marion Farr (U.S. Agric. Res. Serv.), J. E. Grasse (Wyo. Game & Fish Comm.), M. C. Hammond (U.S.F. & W.S.), H. C. Hanson (Ill. Nat. Hist. Surv.), C. M. Hart (Calif. Dept. Fish & Game), C. M. Herman (U.S.F. & W.S.), R. A. McCabe (U. Wis.), H. S. Mosby (V.P.I.), H. W. Mossman (U. Wis.), J. C. Neess (U. Wis.), D. H. Pimlott (Nfld. Dept. Mines & Res.), J. R. Reilly (N.Y. Cons. Dept.), P. O. Rudolf (U.S. For. Serv.), G. C. Sanderson (Ill.. Nat. Hist. Surv.), C. W. Severinghaus (N.Y. Cons. Dept.), V. E. F. Solman (Canad. Wildl. Serv.), L. K. Sowls (U. Ariz.), R. E. Stewart (U.S.F. & W.S.), A. W. Stokes (Utah St. Agric. Coll.), D. R. Thompson (Wis. Cons. Dept.), R. L. Weaver (U. Mich.), and W. L. Webb (Syracuse U.).

## BACK ISSUES OF SOCIETY PUBLICATIONS

The Wildlife Society still has for sale the following publications at $1.00 each:

Ten-year Index (1937-1946) bound in cloth
Farm Pond Symposium
Symposium on Cycles in Animal Populations

Back issues of the *Journal of Wildlife Management* are now rapidly going out of print. As of July 29, 1956, the Society's inventory was for volumes 1 to 18 as follows:

| Volume | Year | No. 1 | No. 2 | No. 3 | No 4 |
|---|---|---|---|---|---|
| 1 | 1937 | — | — | 2 | 2 |
| 2 | 1938 | 17 | — | — | — |
| 3 | 1939 | — | — | — | — |
| 4 | 1940 | 109 | 116 | 106 | 110 |
| 5 | 1941 | 4 | 6 | — | 1 |
| 6 | 1942 | 174 | 169 | 175 | 165 |
| 7 | 1943 | — | 3 | — | 15 |
| 8 | 1944 | — | 3 | 2 | 1 |
| 9 | 1945 | 277 | 240 | 296 | 242 |
| 10 | 1946 | 31 | 513 | 469 | 533 |
| 11 | 1947 | 340 | 354 | 324 | 344 |
| 12 | 1948 | 169 | 78 | 138 | 159 |
| 13 | 1949 | 380 | 367 | 17 | 7 |
| 14 | 1950 | 15 | 35 | 36 | 46 |
| 15 | 1951 | 277 | 355 | 319 | 306 |
| 16 | 1952 | 300 | 315 | 277 | 352 |
| 17 | 1953 | 43 | 196 | 413 | 347 |
| 18 | 1954 | 104 | 219 | 154 | 223 |

The available back issues are priced at $8.00 per volume from volumes 1 to 19, and similarly available issues at $2.00 per issue. Single issues of the current volume may be secured at $1.50 each. Orders should be sent to the Secretary-Treasurer.

—DANIEL L. LEEDY

## INSTRUCTIONS FOR AUTHORS

The Journal publishes sound original articles, discussions, and reviews on wildlife research, management, and administration. The author (or one of joint authors) must be a member of the Society in good standing; exceptions need special approval by the Editor and President (ruling of council, Feb. 16, 1941). In general, papers will be published in order of receipt of copy in final form. Briefer articles may appear somewhat sooner than major articles. Manuscripts requiring major changes will be returned as promptly as possible. Suitability is judged by the content of significant new material, concisely stated, with scientific accuracy and clarity of expression. In problems of spelling, abbreviation, and punctuation, authors are urged to consult the University of Chicago "Manual of Style" or one of the style manuals published by the Canadian government and the U. S. Government Printing Office.

Copy should be typewritten on substantial white paper (8½ inches x 11 inches, or 8 inches x 10½ inches) with *everything* (including tables, footnotes, and bibliographies) *entirely double-spaced*, with margins of about 1½ inches, and with pages numbered at upper right. Care should be taken not to fold a manuscript. Neatness assists both editor and printer in preparing manuscript for publication. Underscore only scientific names. Author's complete address (to which proof is to be sent) should appear at upper left corner of first page. Carbon copies, copies on onion skin, and single spacing are not acceptable. The author should retain a carbon copy for reference, as manuscripts (and illustrations) are not insured.

The title should be concise, descriptive, and not more than 10 words in length, as an aid in bibliography. In general, avoid footnotes by incorporating such material in the text. Where necessary, number them consecutively throughout the article. Acknowledgments are best given in the introduction or a brief footnote to the title. Headings should be few, and of only two or three classes. Articles of more than 5 or 6 typed pages should have a concise summary, understandable without reference to the text, preferably organized as a single paragraph, and not exceeding 4 per cent of the length of the manuscript. Vernacular names of plants and animals should be accompanied by appropriate scientific names the first time each is mentioned in the text, the source of plant names being cited.

Tables should be few, of simple form, with concise headings and a minimum of columns, and prepared in keeping with the size of the Journal column or page. Type each table (or 2 small ones) on a separate sheet. Vertical table lines should be avoided if at all possible. Duplication of data in text, tables, and charts is rarely necessary and usually will result in return of a manuscript for elimination. Long tables of food materials or plants are rarely of general interest; short lists, with pertinent comments, are preferable. Percentages should not imply greater accuracy than the original data; 0.1 per cent means "parts per thousand," a measure rarely attained in wildlife research; in tables, indicate items of 0.1 per cent or less as "traces" (tr.).

References to literature, if one or two, may be inserted in parentheses at the proper places in the text. For a list of literature cited, arrange the entries in alphabetical sequence by authors' surnames and dates; each should include the full title, the name of the journal or place and publisher of a book, and the volume and paging. See recent issues of the Journal for style. All references should be checked carefully against original sources just before the manuscript is sent to the Journal.

Copy for illustrations should be suitable for photographic reproduction without retouching, redrawing, or setting type at the margins. Line drawings should be in India ink, on white drawing paper or bristol board, and planned for column (2⅝ in.) or page (5½ in.) width when reduced. Copy should not exceed 8½ in. x 11 in. Make letters and numbers large enough to be at least 1/16 in. tall when reduced. For graphs, use white paper, tracing cloth, or blue cross-ruled paper; orange or green cross-rulings do not reproduce well. A minimum of photographs for illustrations will be accepted because of the high cost of reproduction. Submit prints of good contrast on glossy paper not exceeding 5 in. x 7 in. Identify each drawing or photograph on the back lightly in pencil ("Jones, muskrats, fig. 4"); do not paste on cards or sheets. Type legends as paragraphs, double-spaced, all in sequence, on a single separate sheet. Put all tables, illustrations, and legends at the end of the article. The entire manuscript may be stapled together in the upper left-hand corner.

Proof should be read, compared and corrected, signed by the author, and sent promptly, with the manuscript, to the Editor, together with an abstract on a form supplied with the proof. The galley-proof stage is not the proper time for editorial changes by the author. Changes or additions to the proof often require resetting of type, the cost of which will in excessive cases be charged to the author. Any major alteration needed is preferable at the end of a paragraph or as a new paragraph.

A form, sent with the proof, provides for ordering reprints. Correspondence about reprints should be sent to the printer (Allen Press, Lawrence, Kansas). Sample costs for reprints are as follows: 4 pages, 100 copies, $6.98; each additional 100, $3.80; 8 pages, $9.90, $5.00; 16 pages, $12.65, $8.00. Covers (Journal stock), $6.90, $3.60. Special rates are available for long runs. Postage will be charged at cost.

## THE WILDLIFE SOCIETY

The Wildlife Society was founded on February 28, 1937. Its principal objectives are: (a) establishment of professional solidarity and maintenance of the highest possible professional standards; (b) development of all types of wildlife management along sound biological lines; (c) publications to effect these ends; and (d) protection of the interests of its members. These purposes are served by annual meetings, regional meetings, correspondence between members, and publication of the quarterly Journal of Wildlife Management and of the quarterly Wildlife Society News.

Any member may become a *Life Member* by paying the sum of $100.00 at one time or in four equal annual installments into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

*Membership* is open to any interested person who is sponsored by two Members; dues are $6.00 annually of which $5.00 is a subscription to The Journal of Wildlife Management, and 50 cents is a subscription to The Wildlife Society News. *Honorary Members* are persons recognized for distinguished service or outstanding achievement in wildlife management. All classes of members receive The Journal and News. Applications for membership should be made to the Secretary-Treasurer.

The Society is governed by a Council composed of the President, Vice-President, Past President, Secretary-Treasurer and seven Regional Representatives, one from each of the six regions in the United States, and one from Canada.

### Officers

*President:* Durward L. Allen, Dept. of Forestry and Conservation, Purdue Univ., Lafayette, Indiana.
*Vice-President:* John S. Gottschalk, U.S. Fish and Wildlife Service, Washington 25, D.C.
*Past President:* Justin W. Leonard, Michigan Dept. of Conservation, Lansing 26, Mich.
*Secretary-Treasurer:* Daniel L. Leedy, U.S. Fish and Wildlife Service, Washington 25, D.C.

### Regional Representatives

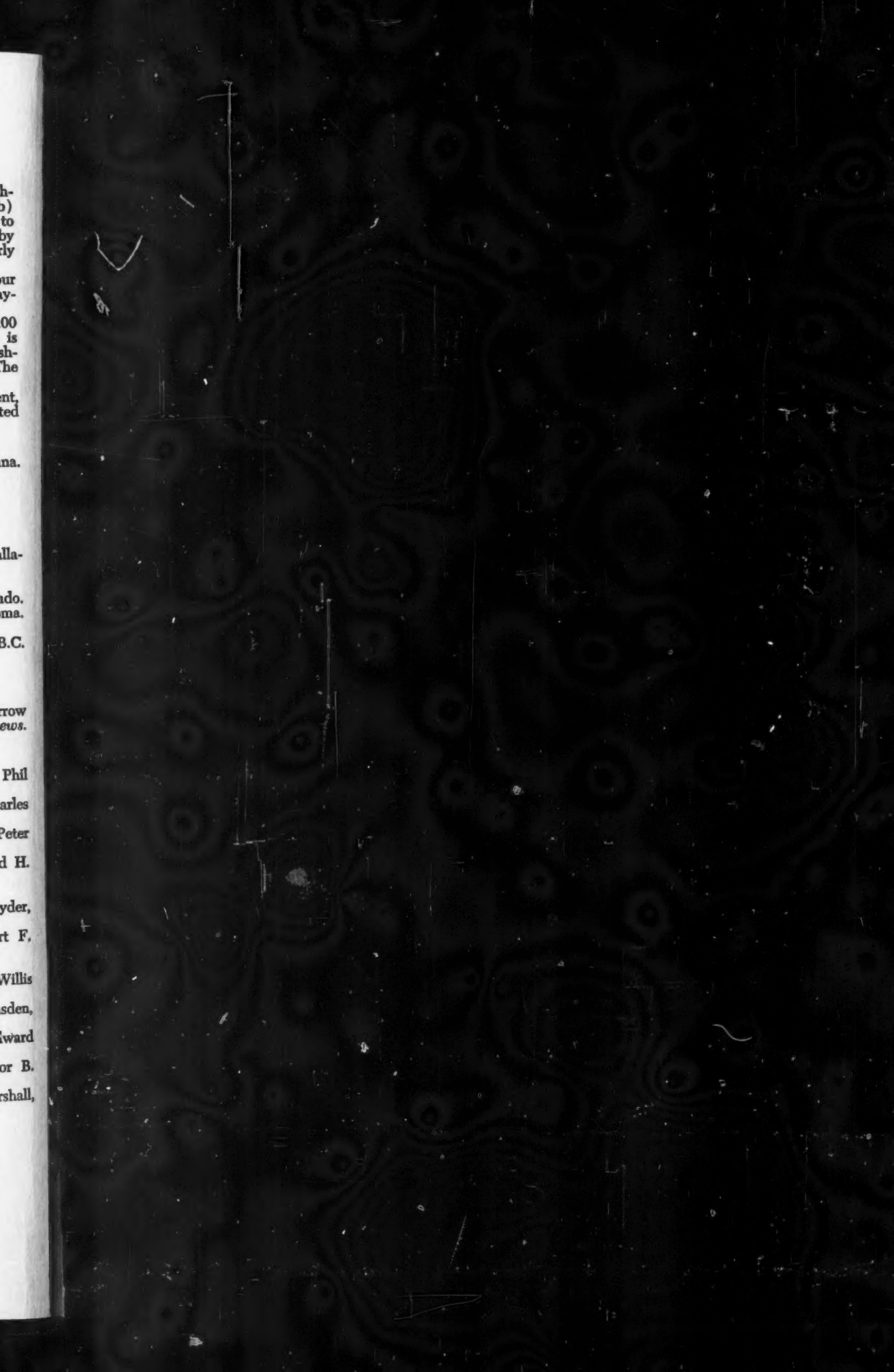
Roger M. Latham (Region 1, northeast), Pennsylvania Game Commission, Harrisburg, Pa.
E. B. Chamberlain (Region 2, southeast), Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.
Bill T. Crawford (Region 3, north central), Wildlife Conservation Bldg., Columbia, Missouri.
Lee E. Yeager (Region 4, northern great plains), Colorado A. & M. College, Fort Collins, Colorado.
Frederick M. Baumgartner (Region 5, southwest), Oklahoma A. and M. College, Stillwater, Oklahoma.
A. Starker Leopold (Region 6, far west), Museum of Vertebrate Zoology, Berkeley, California.
I. McT. Cowan (Region 7, Canada), Dept. of Zoology, University of British Columbia, Vancouver, B.C.

### Trustees

C. R. Gutermuth, 1957; E. H. Graham, 1958; E. R. Kalmbach, 1959.

### Editorial Staff

Joseph J. Hickey, Editor, *Journal of Wildlife Management;* Louis A. Krumholz, Robert W. Darrow and Edward L. Kozicky, Associate Editors; Thomas R. Evans, Editor, *Wildlife Society News.* Henry S. Mosby, Editor-in-chief, *Manual on Wildlife Techniques.*

### Committees

*Leopold Medal Award:* Edward H. Graham, Chairman; Victor H. Cahalane, Arnold L. Nelson, Phil W. Schneider, Victor E. F. Solman.
*Terrestrial Publications Award:* A. W. F. Banfield, Chairman; A. E. Borell, John L. Buckley, Charles O. Handley, Sr., Allen W. Stokes.
*Fishery Publications Award:* George W. Bennett, Chairman; Merle A. Gee, Gustave Prevost, Peter I. Tack.
*Conservation Education Publications Award:* Farley F. Tubbs, Chairman; Anton De Vos, Howard H. Michaud, Leslie Pengelly, Charles F. Yocom.
*Memorials:* Leonard E. Foote.
*Employment:* John R. Langenbach, Chairman; John T. Emlen, Earle O. Frye, Jr., Albert E. Hyder, Robert L. Jones.
*Job Standards:* La Verne Brugger, Chairman; Thomas S. Baskett, Floyd B. Chapman, Robert F. Cooney, Willard D. Klimstra.
*Membership:* Charles A. Dambach, Chairman; and Regional Representatives.
*Nominations:* Hayden W. Olds, Chairman; E. L. Cheatum, C. David Fowle, John E. Chattin, Willis King.
*Resolutions:* Fred R. Cagle, Chairman; Charles H. Callison, Thomas L. Kimball, Harry G. Lumsden, Harlow B. Mills.
*Wildlife Terminology:* Louis A. Krumholz, Chairman; Robert W. Darrow, Oliver H. Hewitt, Edward L. Kozicky.
*Revision of Constitution and Bylaws:* C. H. D. Clarke, Chairman; Frank C. Edminster, Victor B. Scheffer.
*Wildlife Monographs:* G. A. Swanson, Chairman; K. D. Carlander, C. H. D. Clarke, W. H. Marshall, R. H. Stroud.
*Index:* A. W. Stokes, Chairman; O. B. Cope, G. H. Kelker, J. B. Low.
*Exotics:* S. C. Whitlock, Chairman.
*Audit:* F. A. Glover, Chairman; C. G. Fredine, Michael Nadel.
*Award Certificates:* Paul Hickie, Chairman; D. L. Leedy, Bob Hines.
*Chairman, Technical Sessions, 22nd N. Amer. Wildlife Conference:* Lloyd W. Swift.